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(54) **ULTRASOUND BREAST DIAGNOSTIC SYSTEM**

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(57) **ABSTRACT**

To provide an ultrasound breast diagnostic system suitable for screening of breast cancer and minimizing the burden on the doctor examining the captured image. An ultrasound breast diagnostic system comprises an ultrasound breast imaging apparatus having a water bath into which left and right breasts can be dipped downward and an ultrasound probe so disposed on the bottom of the water bath to mechanically scan and adapted to three-dimensionally image the whole region of the breasts by transmission/reception of ultrasound wave, a breast voxel data creating device for creating voxel data on the entire breasts from image data acquired by the apparatus, and a display device used for interpretation of images for displaying an image for examination from the past voxel data and present voxel data on the breasts of the same subject created by the device.

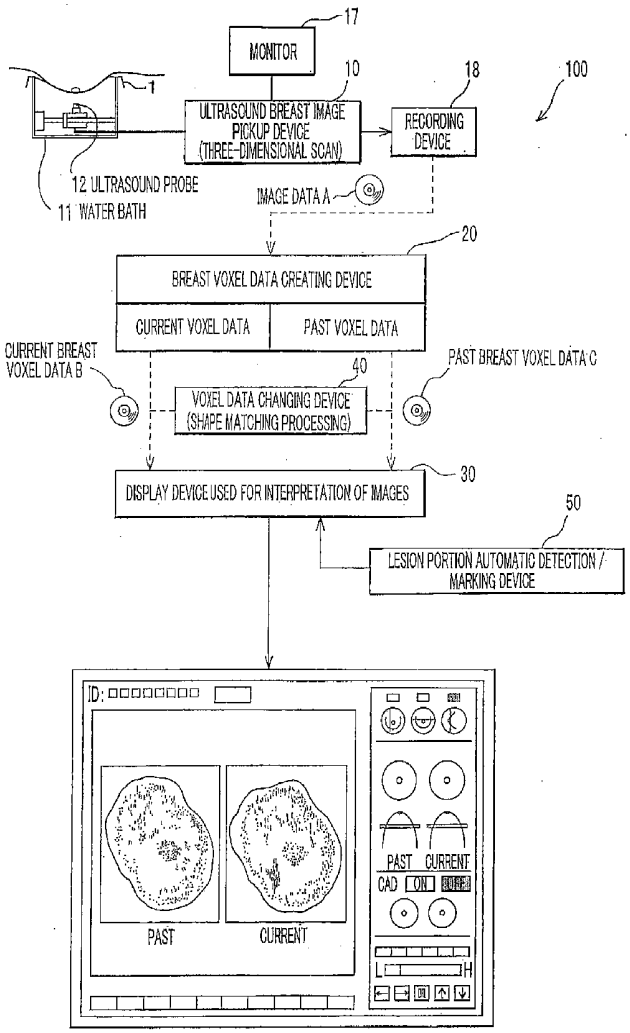


FIG.1

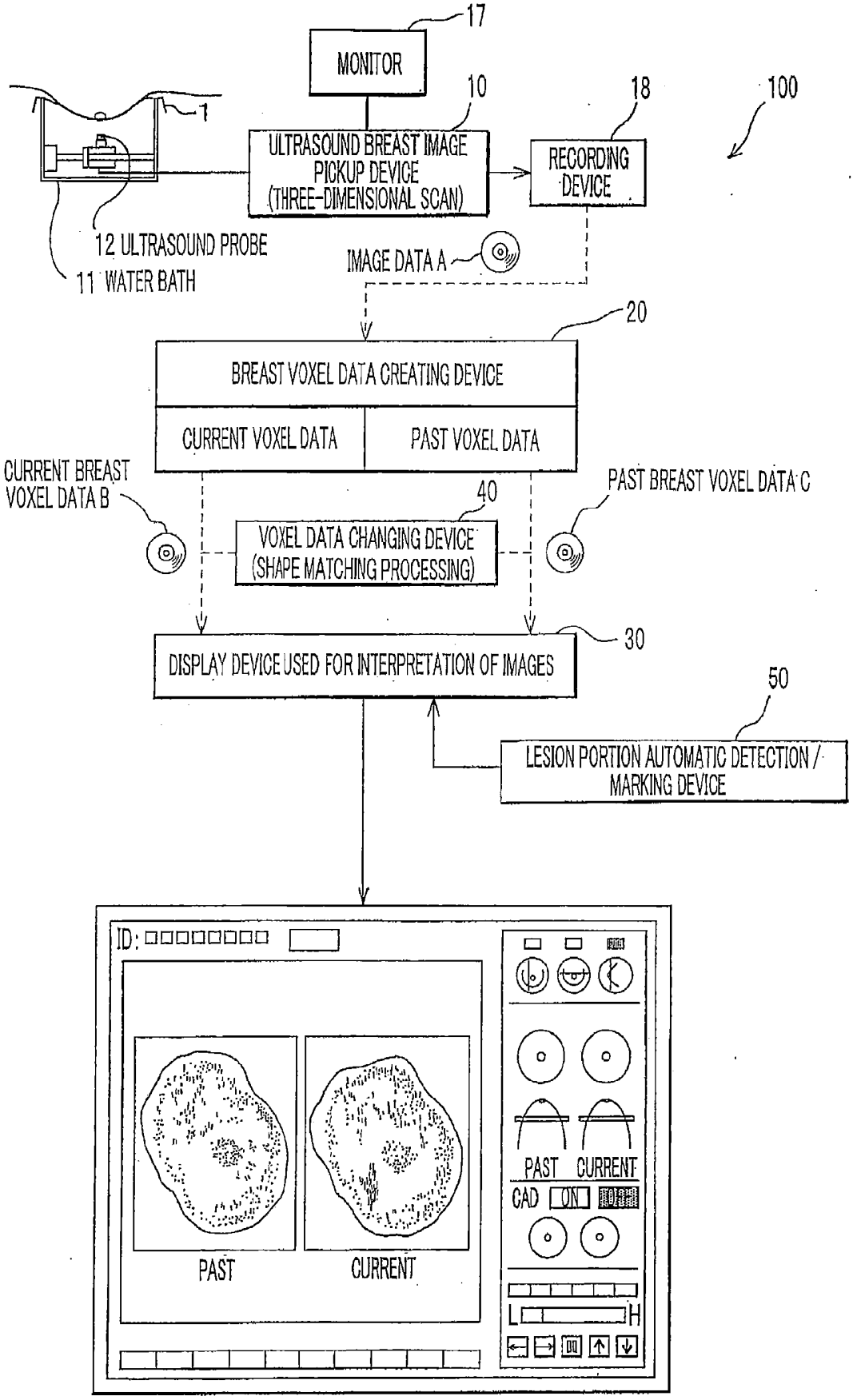

17
MONITOR
10
18
100
1
ULTRASOUND BREAST IMAGE PICKUP DEVICE (THREE-DIMENSIONAL SCAN)
RECORDING DEVICE
12 ULTRASOUND PROBE
11 WATER BATH
IMAGE DATA A
20
BREAST VOXEL DATA CREATING DEVICE
CURRENT VOXEL DATA
PAST VOXEL DATA
CURRENT BREAST VOXEL DATA B
PAST BREAST VOXEL DATA C
40
VOXEL DATA CHANGING DEVICE (SHAPE MATCHING PROCESSING)
30
DISPLAY DEVICE USED FOR INTERPRETATION OF IMAGES
50
LESION PORTION AUTOMATIC DETECTION / MARKING DEVICE
ID:
PAST
CURRENT
PAST
CURRENT
CAD
ON
L
H

FIG.2

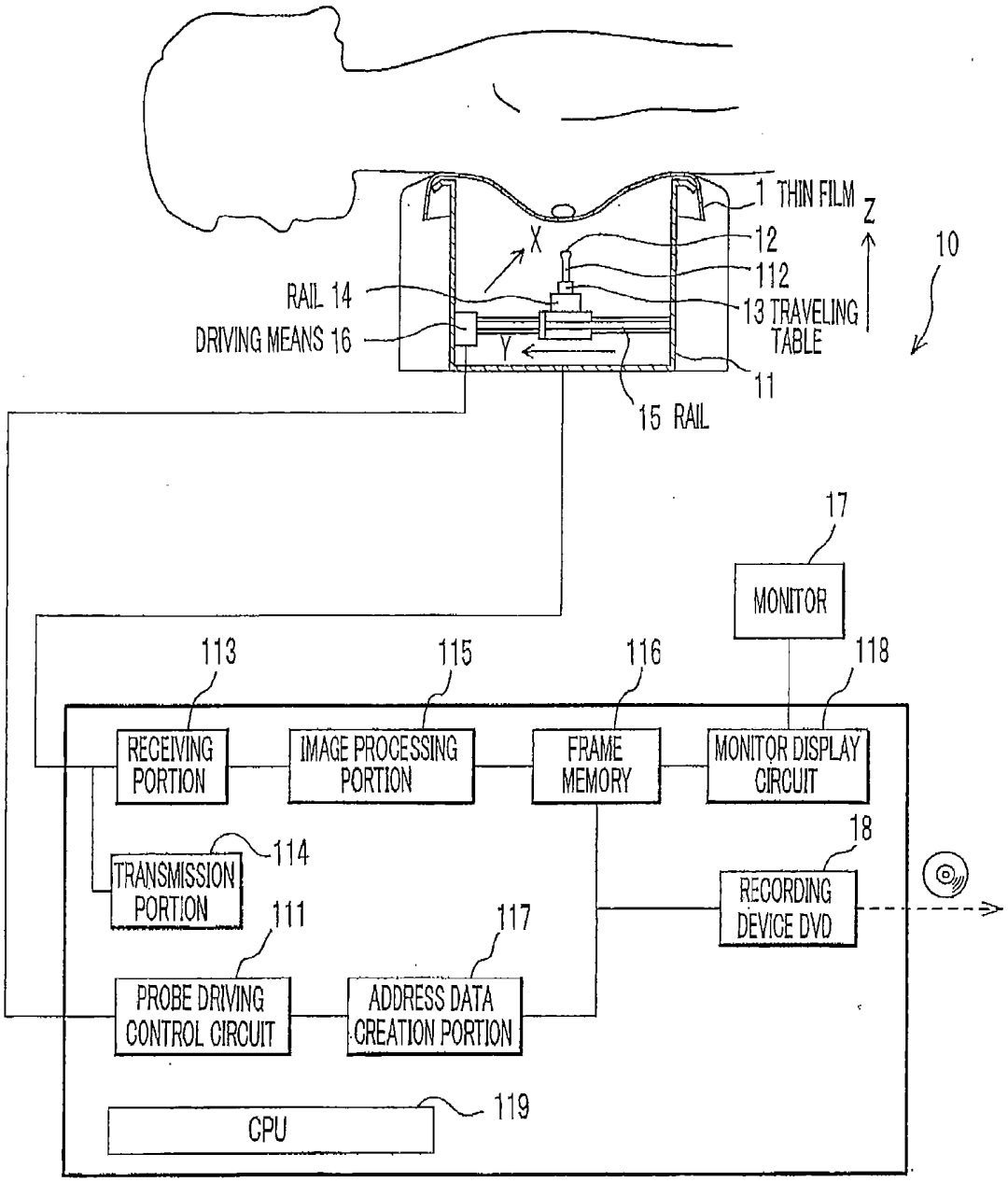

1 THIN FILM
Z
X
12
10
112
RAIL 14
13 TRAVELING TABLE
DRIVING MEANS 16
Y
11
15 RAIL
17
MONITOR
113
115
116
118
RECEIVING PORTION
IMAGE PROCESSING PORTION
FRAME MEMORY
MONITOR DISPLAY CIRCUIT
18
114
TRANSMISSION PORTION
RECORDING DEVICE DVD
111
117
PROBE DRIVING CONTROL CIRCUIT
ADDRESS DATA CREATION PORTION
119
CPU

FIG.3

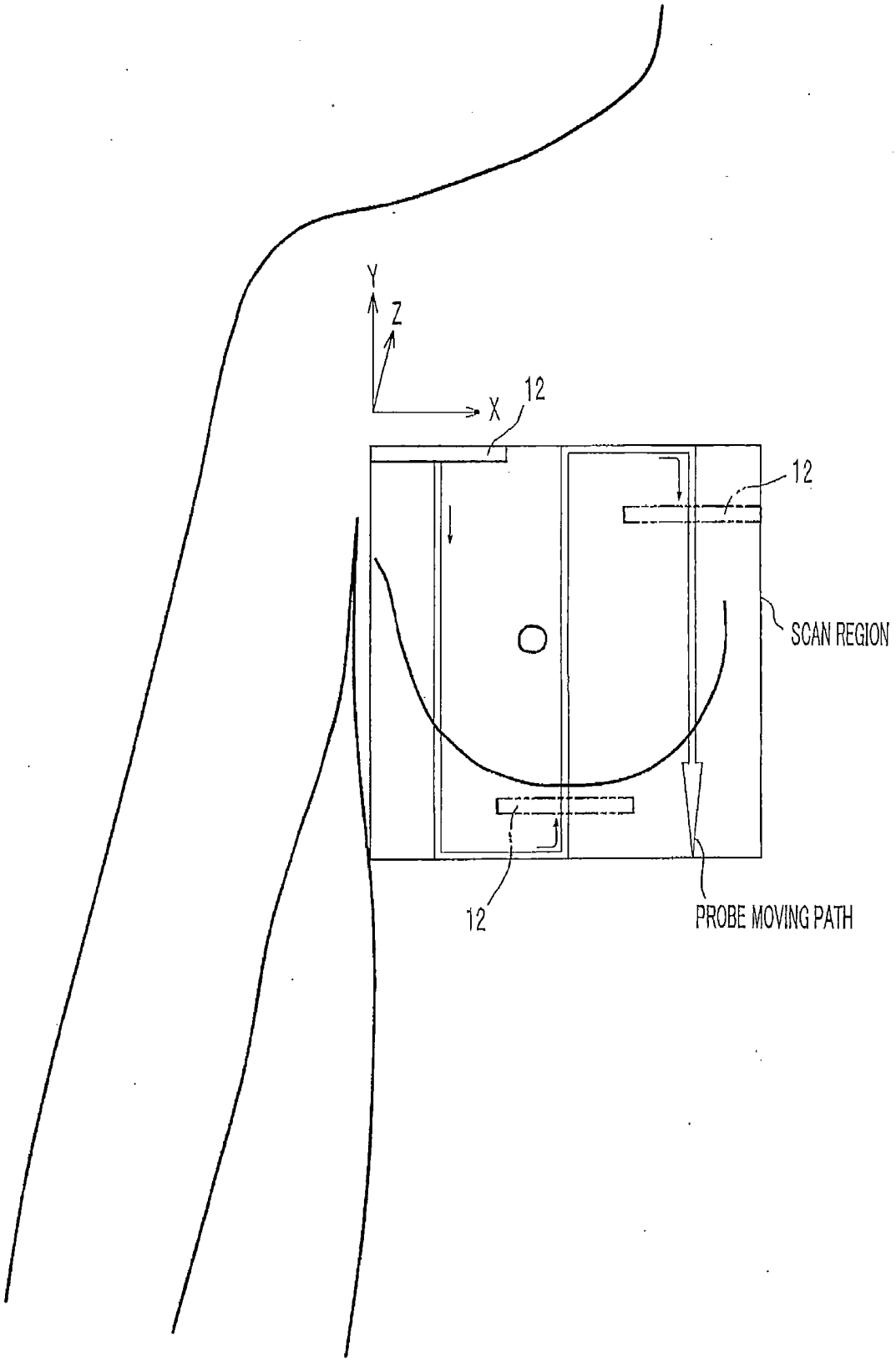


FIG.4

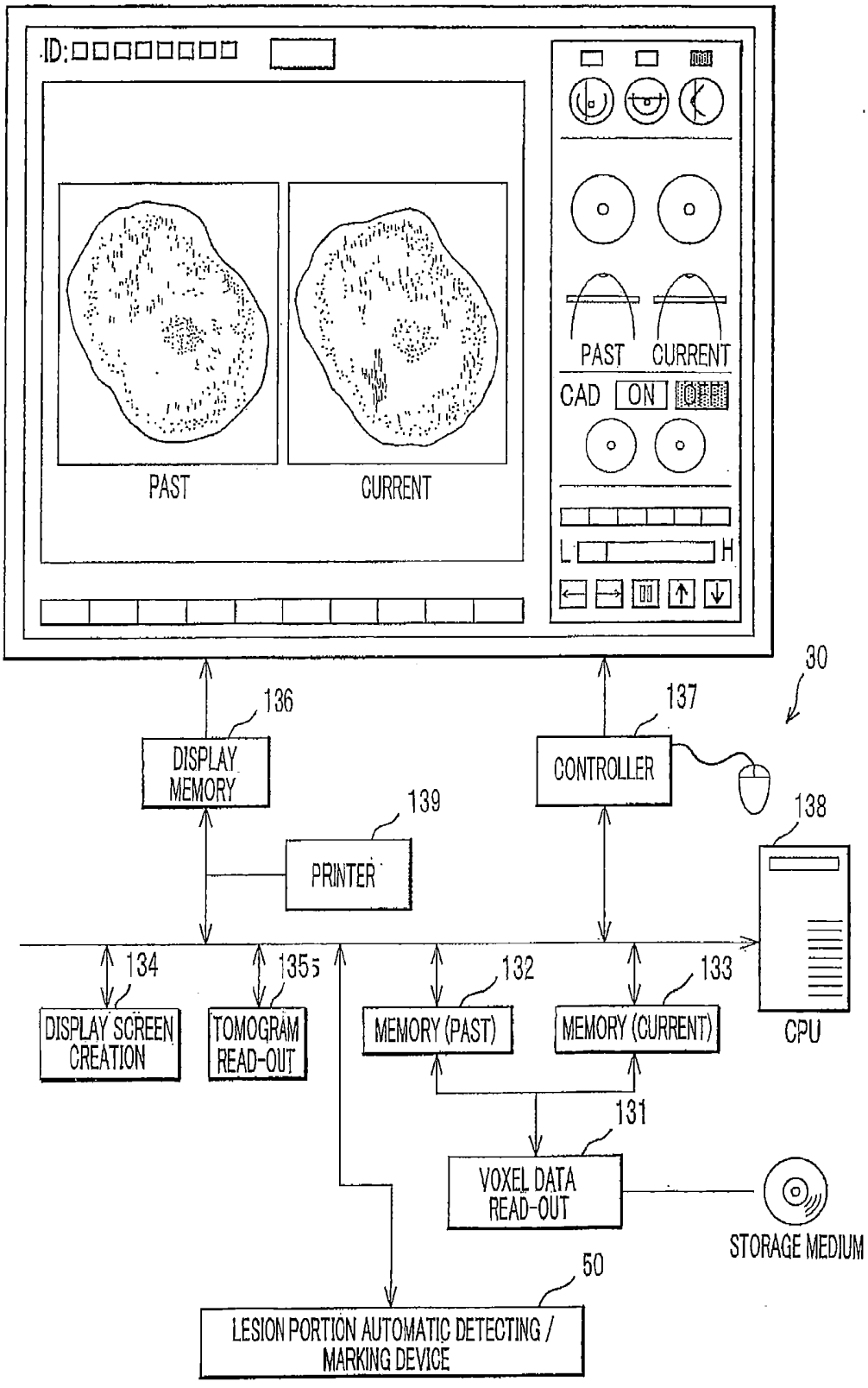

ID:
PAST
CURRENT
PAST
CURRENT
CAD
ON
OFF
L
H
30
136
137
DISPLAY MEMORY
CONTROLLER
139
138
PRINTER
134
135
132
133
DISPLAY SCREEN CREATION
TOMOGRAM READ-OUT
MEMORY (PAST)
MEMORY (CURRENT)
CPU
131
VOXEL DATA READ-OUT
STORAGE MEDIUM
50
LESION PORTION AUTOMATIC DETECTING / MARKING DEVICE

FIG.5

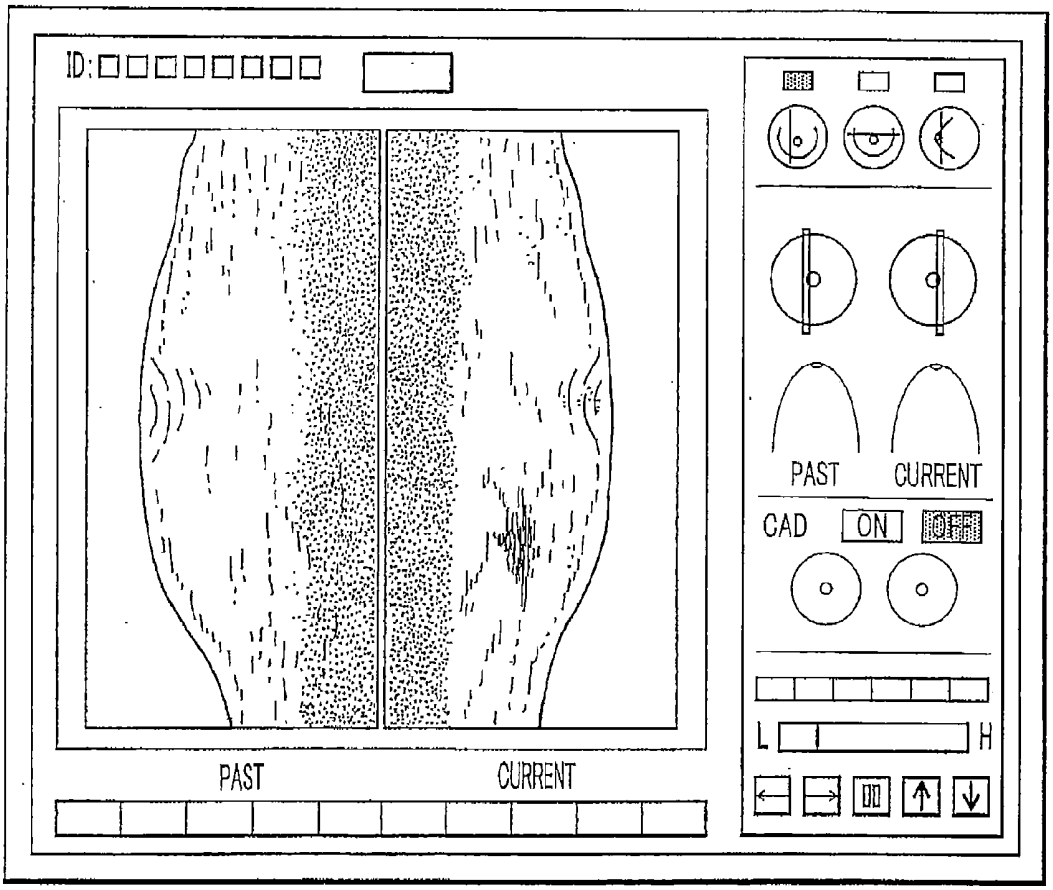


FIG.6

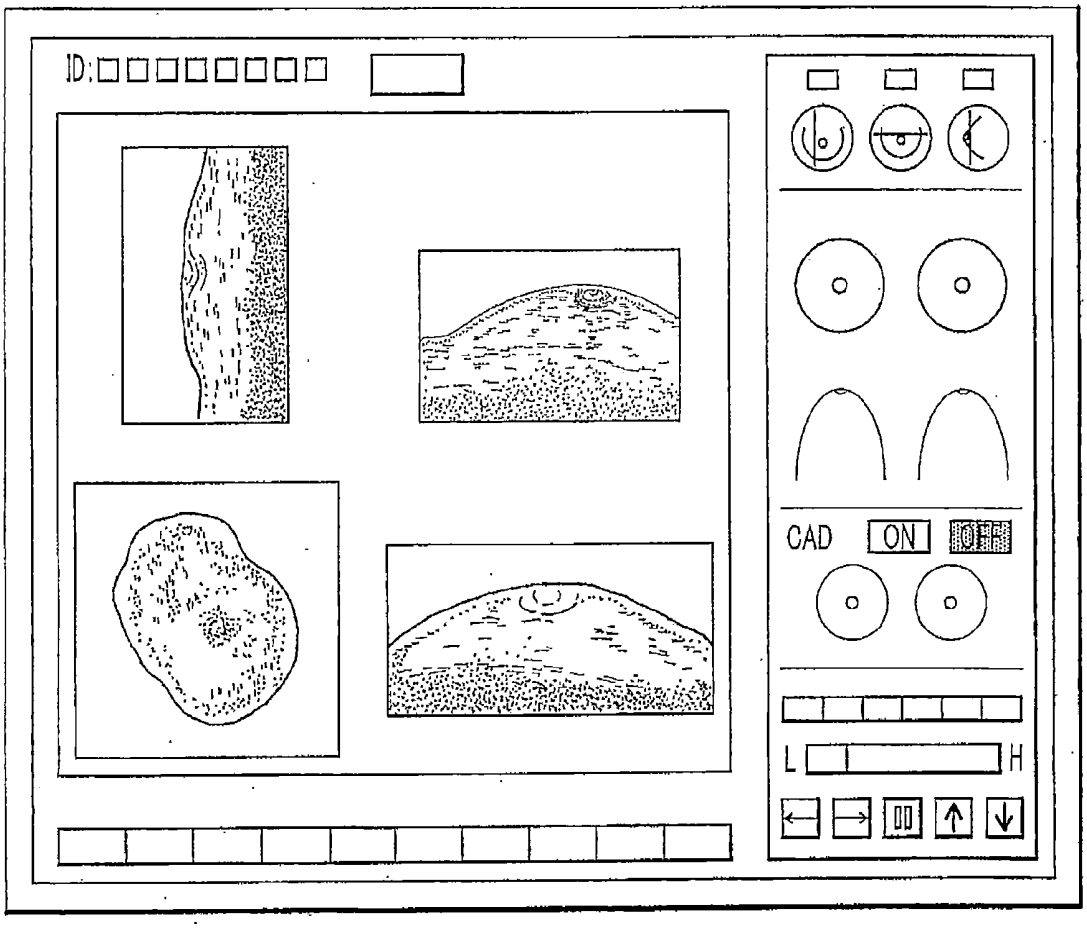


FIG.7

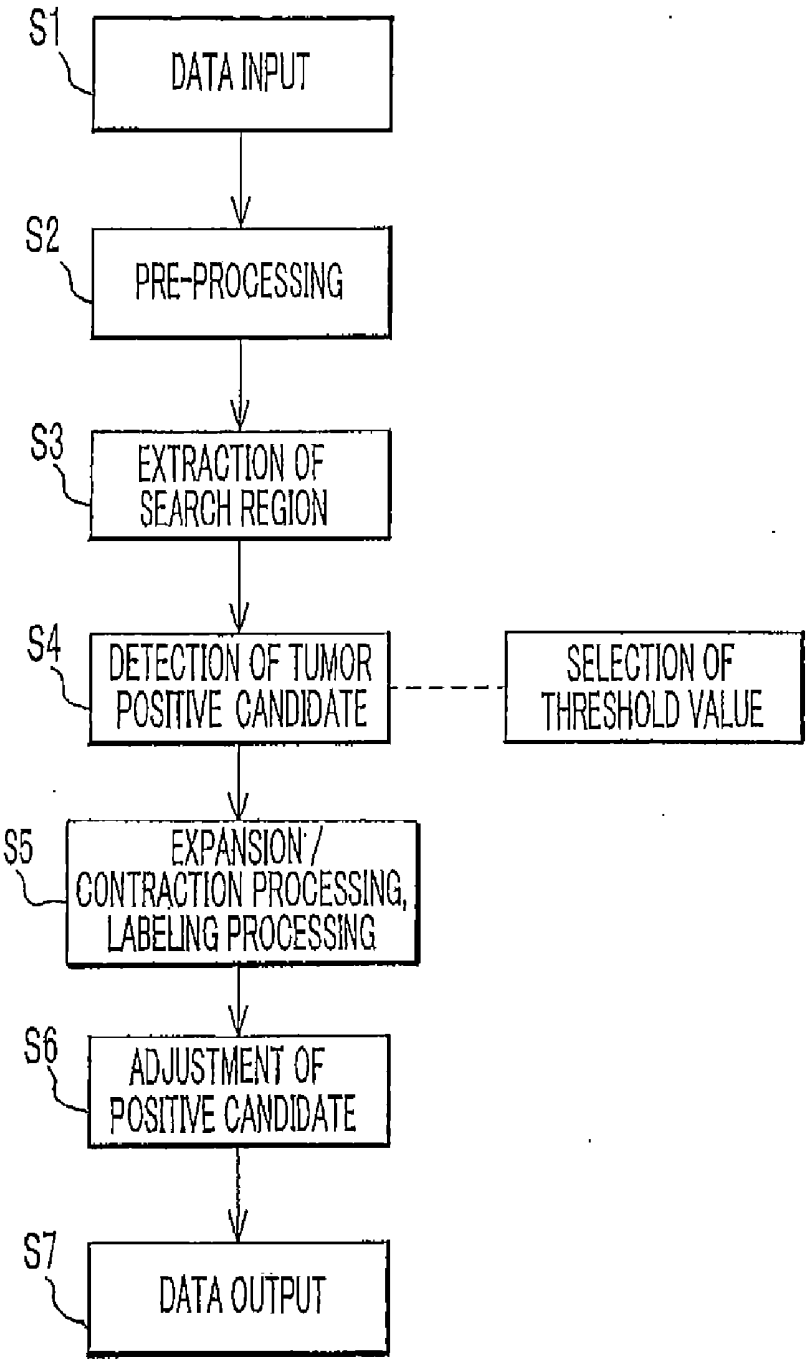
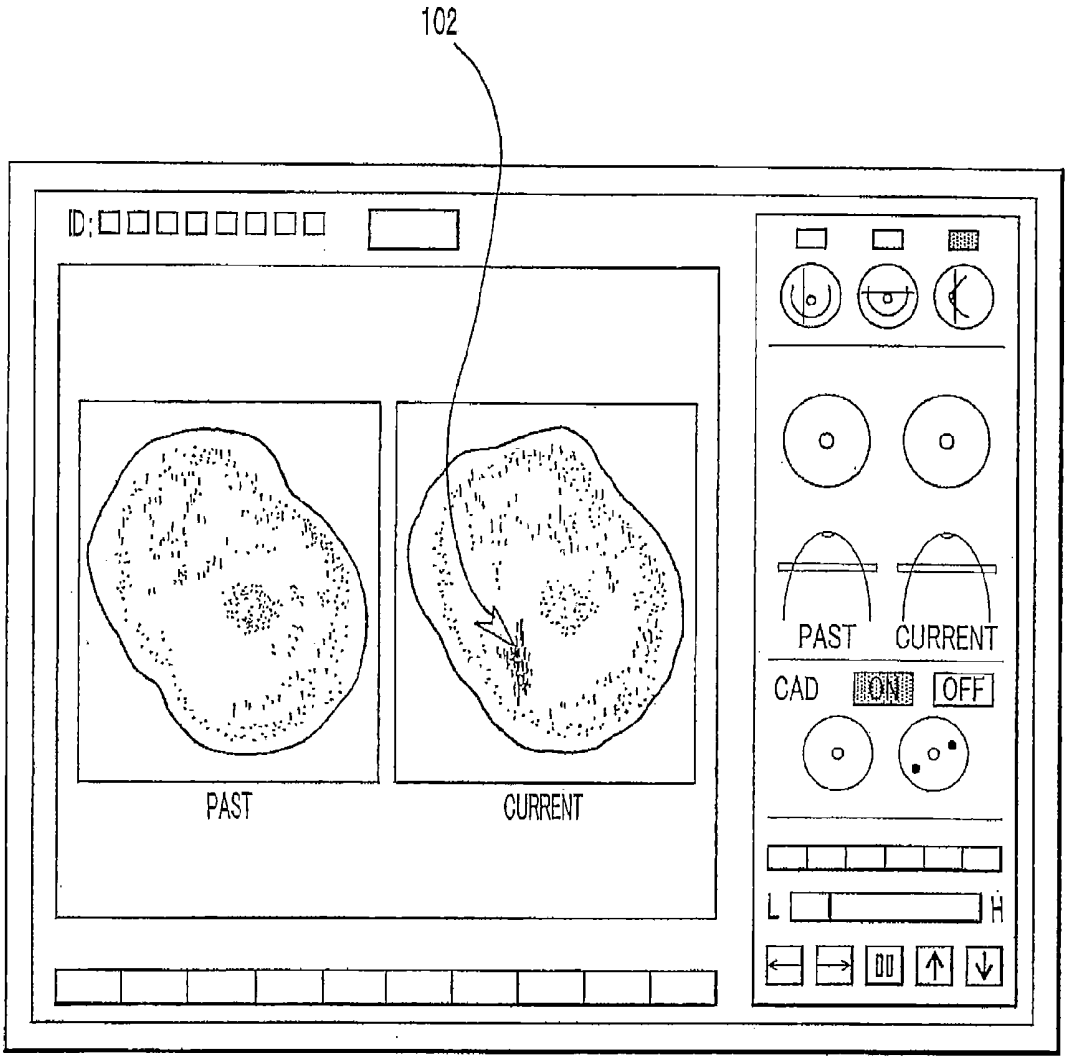

S1
DATA INPUT
S2
PRE-PROCESSING
S3
EXTRACTION OF SEARCH REGION
S4
DETECTION OF TUMOR POSITIVE CANDIDATE
SELECTION OF THRESHOLD VALUE
S5
EXPANSION / CONTRACTION PROCESSING, LABELING PROCESSING
S6
ADJUSTMENT OF POSITIVE CANDIDATE
S7
DATA OUTPUT

FIG.8



ULTRASOUND BREAST DIAGNOSTIC SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to an ultrasound breast diagnostic system for diagnosing the presence of a lesion portion in a breast region by using ultrasound waves and particularly to an ultrasound breast diagnostic system suitable for use in screening of breast cancer.

BACKGROUND ART

[0002] Breast cancer ranks first in cancer morbidity (female) and its early detection is one of major objects in the medical field. Recently, examination by mammography, which is an X-ray transmission image, has been used as effective means for early detection. Using this method, not only small tumors that can not be detected by palpation but also fine calcification which might be malignant can be detected.

[0003] On the other hand, radiogram examination diagnosis by using an ultrasound image (tomographic image) obtained by transmission/reception of ultrasound waves, that is, ultrasound examination is non-invasive means and has been also known as effective particularly for diagnosis of a tumor. Furthermore, if ultrasound examination is to be applied to screening of breast cancer, it is important to pick up a full image of an entire breast region and various proposals relating to technologies with such a purpose have been made.

[0004] A typical example is a mammary ultrasound image pickup method called a "water bath type" described in Patent Document 1, for example, in which a breast is immersed downward in a water bath, and the entire breast region is imaged by performing mechanical scanning with an ultrasound probe arranged below it. The water bath type is characterized in that though the breast is immersed in the water with a soft thin film interposed therebetween in order to retain a shape of the breast, the entire breast can be imaged in a substantially natural bulge. According to the document, an obtained ultrasound image (B-mode image) is displayed on a monitor as a moving image or recorded once and then, used for image diagnosis by being replayed and displayed.

[0005] Also, according to the "water bath type", since an obtained C-mode image is a coronal image, which is a cross-section of a breast, Patent Document 2 discloses a method for obtaining an appropriate number of C-mode images (coronal images) with a predetermined pitch from a mammilla to a breast bottom portion and use of them for screening of breast cancer.

[0006] Also, unlike the above technology in which a probe is used for mechanically scanning the breast in a non-contact manner with water as an acoustic coupling medium, an ultrasound image pickup method of mechanically scanning a probe in contact with the surface of the breast is well known. Patent Document 3 is a typical example, which discloses a technology in which an ultrasound probe provided with a position sensor is mechanically scanned along the surface of a breast of a subject positioned face up or on their stomach so as to image a breast region. The mechanical scanning of the probe is for scanning at a uniform speed along the surface of the breast, but the mechanical scanning is performed in 5 rows specifically for the scanning of the entire region of the breast. In addition, a large number of ultrasound images (B-mode images) picked up with a predetermined pitch for each row are recorded once and then, continuously displayed for image diagnosis. With this type of image pickup method, since the scanning of the probe is performed under a certain pressure so as to maintain a close contact state with the breast surface, an obtained image is different from an original shape of the breast.

[0007] Patent Document 4 discloses a medical information system including automatic detection of a past image and display of it for easy comparison during image diagnosis of an interpretation of images of a patient (the medical images handled here are specifically X-ray images of a gaster and a lung). In addition, Patent Document 5 discloses that an ultrasound image is recorded together with diagnostic information such as annotation or probe position and the like and past images are searched using the diagnostic information as a key and displayed in parallel with the ultrasound image of a subject under examination.

[0008] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2002-336256 (FIG. 1, paragraph [0021])

[0009] Patent Document 2: Japanese Unexamined Patent Application Publication No. 58-58033 (FIGS. 1, 4, page 3, upper right column, lines 8 to 14)

[0010] Patent Document 3: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2004-516865 (FIGS. 1 to 5, paragraph [0052])

[0011] Patent Document 4: Japanese Unexamined Patent Application Publication No. 5-324785 (paragraph [0009])

[0012] Patent Document 5: Japanese Unexamined Patent Application Publication No. 2005-270421 (Abstract)

DISCLOSURE OF INVENTION

Problems to be Solved by the Invention

[0013] Various proposals on the technology in which image diagnosis with ultrasound waves are applied to screening particularly of breast cancer have been made as mentioned above. However, despite these proposals, the ultrasound examination is not used as primary screening means of breast cancer but remains at a level of real-time examination by a hand-probe scanning, re-confirming means of a lesion portion or a positive candidate portion found by palpation or X-ray mammography or means for determining necessity of biopsy at present.

[0014] One of the reasons is that examination of an ultrasound image itself is not easy. That is, since inside a breast is made up of fine and dense tissues in which mammary glands, fat tissue, connective tissues and moreover, blood vessels and nerves are combined together, an ultrasound image based on a sound-ray echo generated between tissues with different acoustic impedances is formed as an image with a variety of textures, and moreover, the image is different depending on the person and the age. Also, the inside the breast is a so-called acoustic chamber, and shades such as speckle noise based on an interference wave and artifact by multiple reflection, not representing a tissue structure of a breast, are generated. Such unique ultrasound images can not be examined easily without sufficient skills.

[0015] Also, with the ultrasound image, unlike the X-ray mammography representing the entire breast in a single image, the number of images requiring examination is large, which is also a major reason. That is, the ultrasound image representing a fine and dense tissue structure of the breast can not be three-dimensionally image-processed like MIP

(MinIP) processing, and a large number of tomograms should be examined in order to examine the entire breast for screening. For example, when a breast region with an entire width of 16 cm is to be examined by a 2 mm-pitch cross section, 80 ultrasound images (tomograms) need to be examined, and if the probe scanning is performed with 5 rows as in the above Patent Document 3, as many as 400 images in total need to be examined. This is an extreme burden for doctors in giving diagnosis that a lesion portion as an abnormal portion is discovered or no lesion portion is discovered.

[0016] The ultrasound examination has not been applied to the screening of breast cancer at least in a full scale as above mainly because non-easiness of the examination and the large number of images specific to the ultrasound image. However, the examination by X-ray mammography has a problem not only of radiation exposure but also of inability of accurate image diagnosis of dense breast prevalent in Japanese women. Also, the X-ray photography (compression method) made in a state where a breast region is pulled out to the body surface side and sandwiched and tightened between upper and lower or right and left plates is more or less painful for women not only in a young generation, which is another problem. Thus, the breast cancer screening by ultrasound waves still attract high expectations particularly in our country where examination on the young generation is also being discussed (The breast cancer screening by MRI (magnetic resonance imaging) has been known recently, but MRI needs contrasting, and examination is not easy. Thus, MRI is suitable for examination on progress of a lesion (higher examination) but not for screening (primary examination, screening)).

[0017] An object of the present invention is to provide an ultrasound breast diagnostic system particularly suitable for breast cancer screening and an ultrasound breast diagnostic system that can minimize a burden on a doctor interpreting of images by displaying an ultrasound image in an optimal form for interpretation of images.

Means for Solving the Problems

[0018] The present invention was made by focusing on the fact that comparison with an image of a normal tissue as a reference image is the most effective in detecting abnormality or diagnosis as no abnormality in a mammary tissue but in an ultrasound image with a large difference depending on the portion or the person, a past image diagnosed as no abnormality and of a corresponding portion is the most suitable for the reference image.

[0019] That is, an ultrasound breast diagnostic system of the present invention in order to solve the above problems basically comprises the following devices:

(a) an ultrasound breast image pickup device provided with a water bath in which a breast can be immersed downward and an ultrasound probe arranged at a bottom portion of the water bath, capable of performing mechanical scanning, for imaging an entire region of a breast in a three-dimensional manner by transmission/reception of ultrasound waves.

(b) a breast voxel data creating device for creating voxel data of the entire breast on the basis of image data obtained by the ultrasound breast image pickup device.

(c) an display device used for interpretation of images for image diagnosis on the basis of current and past voxel data of a breast of the same subject created by the breast voxel data creating device in which tomograms in a predetermined direction of the current breast to be diagnosed are sequentially displayed with a predetermined pitch from one end side to the other end side and the past tomogram of a cross-sectional spot corresponding to the tomogram is displayed in parallel (claim **1**).

[0020] Here, the ultrasound breast image pickup device in the above (a) is a known "water bath type" image pickup device in the above Patent Documents 1 and 2 and the like. With this type of devices, a breast is immersed in water with a thin film such as a rubber film interposed in order to retain its shape in general, but the shape retention is not necessarily required. According to this device, since the probe scanning is performed not in contact with the breast, three-dimensional image data of the entire breast in a round form close to natural can be obtained. As a probe depth of transmission/reception of ultrasound waves by a probe, a sufficient depth that reaches pectoral muscle and rib is appropriate, and the depth can be generally set to approximately 10 cm including an interposed water phase.

[0021] Considering personal difference in screening, the mechanical scanning range of the probe in this device may be defined as a section of approximately by 16 cm, for example. Thus, the probe provided in this device may have a length of approximately 16 cm so as to realize the mechanical scanning in 1 pass. However, more practically, use of a probe with a scan width of 5 to 6 cm similar to a hand probe of a general-purpose ultrasound diagnostic device is preferable, and it is also preferable in a point that no special change in control circuit is needed, and a freedom in probe scanning can be obtained. In this case, the mechanical scanning of the probe is performed in plural passes with an appropriate overlap.

[0022] The breast voxel data creating device in the above (b) is to create single three-dimensional image data of the entire right and left breasts and it is particularly important when the mechanical scanning of the probe by the ultrasound breast image pickup device is performed in plural passes. More specifically, slice image data of each row obtained with a predetermined pitch along with position data of the probe by the device (a) are synthesized with each other while the overlap portions are overlapped by the breast voxel data creating device (b) and finally created preferably as isotropic voxel data. The synthesis of the overlap portions can be carried out by simple selection and deletion of one of data on the basis of coordinate data but such a method is preferable that the portions are added with weighting of inclination from one side to the other side and divided into equal two parts so that a border line is not visualized. The formed voxel data of the entire breast is used for displaying an image in an arbitrary cross section for image diagnosis and also used for three-dimensional automatic detection of a lesion portion in computer-aided diagnosis (CAD), which will be described later.

[0023] The interpretation of image display device in the above (c) displays a current image of a subject whose image is to be diagnosed in parallel with a past image of the same subject obtained in the previous examination on the basis of the voxel data of the entire breast created by the breast voxel data creating device (b). Here, an image offered as a main image for image diagnosis (tomogram) may be an image of a cross section in a desired arbitrary direction. However, for the voxel data having coordinate axes in the vertical direction, bilateral direction, and anteroposterior direction of a body, a longitudinal sectional plane (section dividing the breast into right and left on a front view, that is, sagittal), a transverse plane (section dividing the breast vertically, that is, axial) or a planar section (section dividing the breast in the anteroposte-

rior direction, that is, coronal) not requiring interpolation or calculation is preferable. Moreover, the coronal (planar section) image among them is the most preferable (claim **2**). The coronal image of the breast is not suitable for determination of state of a rearward echo but extremely suitable for diagnosis of disturbance in the structure of a tissue, which is an initial state of cancer and among them, it has an advantage that the number of images requiring examination is small since it is a genuine tomogram of the breast region.

[0024] However, a sagittal (longitudinal sectional) image or an axial (transverse sectional) image is also a recommended tomogram, and discrimination between benignant or malignant of a tumor and the like can be made from the state of the rear echo. These tomograms are visualized as an image made of a water phase made up of a dark portion substantially without echo, a breast phase, a pectoral muscle and a phase below a rib substantially without echo in order from the probe side, but in this case, the current and past tomograms are preferably displayed adjacently to each other symmetrically vertically or horizontally with the rib sides (breast base sides) made up of the dark portions abutting each other (claim **3**). Thereby, an eye movement during comparison with the past image can be minimized, and an optimal image diagnosis can be made.

[0025] In the device (c), such tomograms are sequentially displayed with a predetermined pitch from one end side to the other end side of a breast region in order to examine the entire region of the breast exhaustively on the presence of a lesion and the like. Here, the pitch of the section can be determined as appropriate according to a size of a lesion portion to be detected, and if a tumor of approximately 5 mm or more is required to be detected, a pitch of approximately 2 to 4 mm is appropriate. Though depending on the voxel size, the smaller this pitch is set, the more precise interpretation of images becomes possible, but the number of images to be examined is increased. It is needless to say that a speed of sequential display is also preferably possible to be set as appropriate by an examiner. Also, in the continuous display, display indicating a section in what spot in the breast the tomogram in display refers to is also preferably made on a screen. The display of the cross-sectional spot may be constituted as a line or a bar crossing a breast mark represented as a circle, for example, in a sectional direction.

[0026] It is important that the past image displayed as a reference image in parallel with the current tomogram as an examination target sequentially displayed as above is an image of a corresponding, that is, the same cross-sectional spot on the premise that the size and form of the breast is not much different between the present and the past. As a result, the past image can be the best reference image in examining a change in a lesion or a tissue.

[0027] According to the water bath type ultrasound breast image pickup device in the above (a), since a breast is imaged in an attitude that the mammilla is located at the center on an upper face of the water bath in general, the past tomogram corresponding to the current tomogram can be an image made up of the same coordinates. However, actually, the position of the breast in imaging is somewhat different, and even if the three-dimensional shape of the breast itself is the same between the current and past images, there is some displacement and the like. Then, the past image corresponding to the current image can simply be an image made up of the same coordinates as those of the current image, but it is more preferable that the mammilla is detected in the current and past images, respectively, so as to have an image with the same distance using the mammilla as a reference (claim **4**).

[0028] Also, there might be a case in which an unignorable difference is caused in the entire shape between the current and past images due to change of the shape retaining condition. If the entire shape is different, it is difficult to specify the corresponding cross-sectional spot. According to one aspect, an ultrasound breast diagnostic system of the present invention further comprises

(d) a past breast voxel data changing device for carrying out non-rigid deformation processing so that the entire past breast shape matches the current shape (claim **5**). The non-rigid deformation processing (shape matching processing) can be carried out by coordinate conversion by linear conversion and interpolation of a voxel concentration value as generally known in the image processing field. And the past image is immediately made into the one corresponding to the current image in terms of coordinates by the device (d). However, it can not be denied that the image data should be somewhat deteriorated by the non-rigid deformation processing.

[0029] According to the ultrasound breast diagnostic system of the present invention for creating each voxel data of the entire right and left breasts, three-dimensional display and the like of any abnormal portion, if detected, can be made. More details and modes of the display used for interpretation of images will be described later as the best mode for carrying out the invention.

[0030] Moreover, a system known as CAD can be introduced to the ultrasound breast diagnostic system of the present invention. That is, the ultrasound breast diagnostic system of the present invention is further provided with the following device:

(e) a lesion portion automatic detecting/marking device that analyzes the voxel data of the breast (current breast to be examined) with computer, automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image (claim **6**).

[0031] Here, the lesion portion is specifically a tumor, and a method for automatically detecting the tumor includes a binarization method, a method on the basis of concentration degree of concentration gradient vector, a method using a three-dimensional Gaussian-Laplace (LoG) filter, a method using texture analysis and the like. In a preferred embodiment, which will be described later, initial detection of a tumor is performed by the binarization method, with which the processing can be executed most easily. Alternatively, the mark indicating the positive candidate of the detected lesion portion may be an arrow whose tip end is directed to the positive candidate or a surrounding line surrounding the positive candidate as having been well-known.

[0032] According to the lesion portion automatic detecting/marking device (e), since the lesion portion is displayed as the positive candidate, a doctor can examine the image referring to that. This further helps alleviate a burden on doctors particularly in screening requiring careful attention so as not to miss a lesion portion.

ADVANTAGES OF THE INVENTION

[0033] According to the ultrasound breast diagnostic system of the present invention, a past tomogram of a corresponding cross-sectional spot in parallel with the current breast tomogram to be examined and sequentially displayed is displayed as a reference image. Thus, since the presence of a lesion portion as an abnormal shade can be diagnosed on the

basis of a difference or a change in the tomogram, accurate diagnosis can be made more easily. That is, even for the ultrasound image in which the interpretation of images itself is not easy and the number of images to be interpreted is large, a burden on a doctor in the interpretation of images can be minimized.

BEST MODE FOR CARRYING OUT THE INVENTION

[0034] A preferred embodiment of an ultrasound breast diagnostic system of the present invention will be described below referring to the attached drawings. FIG. **1** is an explanatory diagram illustrating an outline configuration of the entire ultrasound breast diagnostic system of an embodiment of the present invention.

[0035] An ultrasound breast diagnostic system **100** of this embodiment is adapted for breast cancer examination using ultrasound waves and is provided with, as shown in FIG. **1**, a water bath **11** in which a breast can be immersed downward, an ultrasound probe **12** arranged on a bottom portion of the water bath **11**, capable of performing mechanical scanning in a horizontal plane, an ultrasound breast image pickup device **10** that images an entire region of a breast in a three-dimensional manner by transmission/reception of ultrasound waves, a breast voxel data creating device **20** that creates voxel data of the entire breast on the basis of image data A obtained by the ultrasound breast image pickup device **10**, and an display device **30** for displaying an image for image diagnosis on the basis of voxel data B, C of current and past breasts of the same subject created by the breast voxel data creating device **20**, that sequentially displays tomograms taken in a predetermined direction of the current breast to be examined from one end side to the other end side with a predetermined pitch and displays a past tomogram of a cross-sectional spot corresponding to the tomogram in parallel.

[0036] Also, the ultrasound breast diagnostic system **100** is further provided with a past breast voxel data changing device **40** that carries out non-rigid deformation processing so that the entire shape of the past breast for image diagnosis displayed by the display device used for interpretation of images **30** matches the current shape on the basis of the current and past breast voxel data B, C of the same subject created by the breast voxel data creating device **20**.

[0037] Moreover, the ultrasound breast diagnostic system **100** of this embodiment is further provided with a lesion portion automatic detecting/marking device **50** that analyzes the breast voxel data B, C with a computer, automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on an applicable image for image diagnosis by the display device used for interpretation of images **30**.

[0038] FIG. **2** is an explanatory diagram illustrating an outline configuration of the ultrasound breast image pickup device **10**. FIG. **3** is an explanatory diagram illustrating a mechanical scanning path of the ultrasound probe. The ultrasound breast image pickup device **10** is a so-called "water bath type" image pickup device and as shown in FIG. **2**, picks up an ultrasound image of the entire breast region of a subject in a three-dimensional manner when the subject hunches over an upper opening portion of the water bath **11** and the ultrasound probe **12** arranged on the bottom portion of the water bath **11** is mechanically scanned in a horizontal plane. In FIGS. **2** and **3**, the X direction is the same direction as an electronic scanning direction of the ultrasound probe **12** and also a bilateral direction of the subject in this figure. The Y direction is a cephalocaudal direction of the subject, and the Z direction is a probe depth direction of transmission/reception of the ultrasound wave by the ultrasound probe **12**. For accurate incidence of the ultrasound wave into the breast, the mechanical scanning of the ultrasound probe **12** may be carried out on a curved rail corresponding to the shape of the breast.

[0039] The ultrasound breast image pickup device **10** is provided with the water bath **11** having the upper opening capable of receiving either one of the right and left breasts of the subject and holding water for ultrasound propagation between the ultrasound probe **12** provided inside and the breast, a traveling base **13** on which the ultrasound probe **12** is fixed, a first rail **14** for movably guiding the traveling base **13** in the X direction, which is the same as the electronic scanning direction of the ultrasound probe **12**, a second rail **15** for guiding the first rail **14** in the Y direction orthogonal to the X direction, and driving means **16** for driving the traveling base **13** along the first rail **14** and the second rail **15**. The driving means **16** is made up of a stepping motor. In this embodiment, a thin film **1** with elasticity is extended at the upper opening of the water bath **11** so as to cover the opening for retaining the shape of the breast.

[0040] The device **10** functionally includes a probe driving control circuit **111** for controlling the entire device, an ultrasound probe **112** for transmission/reception of ultrasound waves to/from the subject, a receiving portion **113** and a transmission portion **114** as an ultrasound transmitting/receiving device for obtaining sound-ray data of a cross-sectional image of the subject through transmission/reception of ultrasound waves from the ultrasound probe **112**, an image processing portion **115** for processing the obtained ultrasound image, a frame memory **116** in which the sound-ray data of the tomogram obtained by the image processing portion **115** is sequentially stored, an address data creation portion **117** for receiving an instruction from the probe driving control circuit **111** and supplying address data to the frame memory **116**, a monitor display circuit **118** for displaying the tomograms sequentially stored in the frame memory **116** on the monitor **17**, a CPU **119** for entire control, and a recording device **18** for reading out an image frame from the frame memory **116** and recording it with the address data.

[0041] Here, the ultrasound probe **12** can be mechanically moved in the X direction and the Y direction at a lower part in the water bath **11**. That is, automatic scan is performed mechanically in a plane substantially parallel with the body axis away from the breast by a predetermined distance. In this scanning, since the driving means **16** is made up of a stepping motor, the CPU **119** can obtain the address data in driving control of the ultrasound probe **12** in the scan. Also, since the size of the breast of a subject is different depending on the person, the scan region of the ultrasound probe **12** is made to be in a range of 16 cm vertically and laterally. Tomographic data up to 10 cm including the interposed water phase can be obtained in the depth direction. A slice pitch of the tomographic data can be set as appropriate, but considering that the voxel data to be created in a subsequent process is preferably composed of isotropic voxels, a slice pitch set in accordance with the voxels is preferable.

[0042] The scan width (array length of the transducers) of the ultrasound probe **12** is 6 cm. Thus, as shown in FIG. **3**, the scanning of the ultrasound probe **12** is made in three passes including an overlap portion of approximately 1 cm. The

tomograms of cross-sectional images recorded in an appropriate recording medium by the recording device **18** are stored for a predetermined period as medical images. They are also used for separately creating tomograms for image examination performed later by using the breast voxel data creating device **20** in this embodiment.

[0043] According to the ultrasound breast image pickup device **10**, in a state where the subject hunches over the upper opening portion of the water bath **11**, the ultrasound probe **12** arranged on the bottom portion of the water bath **11** is mechanically scanned under control of the CPU **119** and picks up a plurality of tomograms in a predetermined region (16 cm in width and length×10 cm in depth) of sufficient size to include the entire breast region of the subject, and the breast can be three-dimensionally imaged substantially in a natural shape.

[0044] The breast voxel data creating device **20** creates voxel data on the basis of the tomographic data A by probe scanning performed in three passes. The breast voxel data creating device **20** is made up of a computer device and creates slice image data of each row obtained at a predetermined pitch by overlapping and synthesizing the overlap portions with each other and finally making them into voxel data along with position data of the ultrasound probe **12** by using the ultrasound breast image pickup device **10** by executing an installed program.

[0045] The created voxel data is preferably composed of isotropic voxels. A method of synthesizing the overlap portions is preferably a weighted average method in which "weighting" inclined from one side to the other of an overlap portion is given, not a simple average of pixel values of the applicable spot. The voxel data created as above is held in a storage medium such as a memory of the breast voxel data creating device **20** and used as the current breast or past breast voxel data as appropriate in processing of the display device used for interpretation of images **30** or in processing of the voxel data changing device **40**. The voxel data created by the device **20** may be recorded in a recording medium such as a HDD, DVD or the like. FIG. **1** explains an on-line media method.

[0046] The display device used for interpretation of images **30** displays an image for image diagnosis on the basis of voxel data created by the breast voxel data creating device **20**, and the device sequentially displays tomograms in a predetermined direction of the current breast to be examined from one end side to the other end side with a predetermined pitch and displays a past tomogram of the cross-sectional spot corresponding to the tomogram in parallel. Its hardware configuration is provided with, as shown in FIG. **4**, voxel data read-out **131** for reading out the voxel data from the storage medium, a memory (past) **132** and a memory (current) **133** into which the past and current voxel data read out by the voxel data read-out **131** is written, display image creation **134** and tomogram read-out **135** for displaying the tomogram in the predetermined direction on the basis of the current and past voxel data, a display memory **136** in which a display screen for interpretation of images created thereby is written, a controller **137** for interface between an image examiner and the device **30**, and a CPU **138** for controlling them through a data bus. The lesion portion automatic detecting/marking device **50** and the display device used for interpretation of images **30** are connected to each other through the data bus. The device **30** is also provided with a printer **139** for printing a display image of the display memory **136** so that the display image to be interpreted can be printed.

[0047] Display processing of a primary image by the display device used for interpretation of images **30** is carried out by the CPU **138** executing the installed program as follows. That is, the voxel data of the current and past entire breast created by the breast voxel data creating device **20** is read out by the voxel data read-out **131** and written into the memory (past) **132**, the memory (current) **133**, respectively. The data in the memories **132**, **133** is read out by the tomogram read-out **135** as appropriate, a current tomogram in the predetermined direction and a past tomogram of a cross-sectional spot corresponding to that tomogram are selected, the tomograms are incorporated into the display screen created by the display screen creation **134** and the screen for interpretation is constituted. Furthermore, the interpretation screen is written in to the display memory **136** and displayed as shown in FIG. **4**.

[0048] The screen for interpretation shown in FIG. **4** is divided into a plurality of windows (rectangular regions), which include a "current" region displaying the "current" breast tomogram, a "past" region displaying the "past" breast tomogram, and a region including a list displaying a sectional position of the breast and an operation panel for operation by an examiner such as ON, OFF and the like of CAD (lesion portion automatic detecting/marking device), for example. The tomograms for interpretation incorporated into the regions are the current and past tomograms of each breast of the same subject, and the current breast tomograms are displayed in the "current" region on the display screen for interpretation substantially at the center of the screen, while the past breast tomogram corresponding to the tomogram is displayed in the "past" region substantially in the left thereof.

[0049] Here, in processing to select the past breast image so that the image is the tomogram in the same direction at the spot corresponding to the current image, mammilla detection processing can be carried out. The mammilla is imaged in a state buried in the breast in general under the shape retention by the thin film **1**, and because of that, the mammilla is not necessarily located at the uppermost point on the breast surface. Thus, the mammilla detection processing on the basis of the breast voxel data B, C can be carried out easily by the following method using the fact that a shade is generated in the periphery of the mammilla buried in the breast in the three-dimensional breast image. That is, a search box of such a size that it contains the mammilla region is set at the top portion (center portion) of the three-dimensional breast image, a concentration average value of all the voxels (excluding the water phase) in the search box at each point is acquired while the search box is sequentially moved, and the center of the search box at a portion where the concentration average value is the minimum is determined as the mammilla center. This method is easy in terms of processing among other things and sufficient correctness can be obtained.

[0050] In the image diagnosis displayed in parallel through the above processing, the coronal image is provided as a primary image because the coronal image is extremely suitable for diagnosis of a disturbance in the structure of a tissue, which is an initial state of cancer and among other things, it has an advantage that the number of images required for interpretation can be small since it is a genuine tomogram of a breast region.

[0051] However, a sagittal (longitudinal sectional) image or an axial (transverse sectional) image is also a recommended tomogram, and discrimination between benign and

malignant of tumors and the like can be made from a state of a rear echo. FIG. **5** shows an example of another display screen displayed by the display device used for interpretation of images **30**. In the display example shown in this figure, the sagittal (longitudinal sectional) images are displayed on the right and left in parallel for image diagnosis and the current and past tomograms are adjacently displayed symmetrically vertically or horizontally with the rib sides (breast base sides) made of the dark portions abutting each other. Thereby, eye movement during comparison with the past image can be minimized.

[0052] In a window of the display device used for interpretation of images **30** displaying the breast, tomograms of the breast from axial and other arbitrary directions, not shown, can be displayed. For example, the window is divided into an upper stage in the screen and a lower stage in the screen, and the current right and left breasts of the subject may be displayed on the upper stage in the screen, while the past right and left breasts of the same subjects may be displayed on the lower stage in the screen in parallel. In this case, there may be a window for displaying a differential image between the current and past breasts. These various screen display contents can be selected as appropriate by the examiner such as a doctor or the like by clicking on the operation panel in the window or the screen may be made single so that the section is switched as necessary.

[0053] FIG. **6** is a diagram illustrating an example of three-dimensional display (3D display). If an abnormal portion or the like is detected, the region that has been displaying the current and past tomograms so far is switched to a window showing the three-dimensional display including the abnormal portion instead of the tomograms as shown in FIG. **6**. This window arranges and displays a sagittal image on the upper left side on the upper stage in the screen, an axial image at the center on the upper stage in the screen to the right thereof, a coronal image on the lower left on the lower stage in the screen below the sagittal screen, and a tomogram in an arbitrary direction at the center on the lower stage in the screen to the right thereof. According to the ultrasound breast diagnostic system **100** as above, any abnormal portion, if detected, can be displayed in a three-dimensional manner or the like.

[0054] In this three-dimensional display means, means for indicating and determining a point of interest (point to be three-dimensionally scrutinized) on the screen is provided. When the point to be three-dimensionally scrutinized is indicated and determined using this means, as mentioned above, the "three-dimensional display" is made as in FIG. **6**. On this screen, a scale is displayed movably. Therefore, the size of the lesion portion and a distance from the mammilla can be measured. Also, if the point of interest is identified as a positive candidate region by the lesion portion automatic detecting/marking device **50**, since the region including the point is labeled, data relating to the size and the like can be immediately displayed.

[0055] Also, since the past image displayed by the display device used for interpretation of images **30** is an image corresponding to the tomogram of the current breast, that is, an image of the same cross-sectional spot, it can be compared with the best reference image when the examiner examines the lesion or change in the tissue. There might be an unignorable difference between the current and past images in the entire shape such as a flattening degree due to a change in the shape retaining condition and the like. And if the entire shape is different, it is difficult to specify the corresponding cross-sectional spot. The past breast voxel data changing device **40** in this embodiment solves the problem by non-rigid deformation (three-dimensional shape matching) so that the entire shape of the past breast matches the current shape by image processing.

[0056] This non-rigid deformation can be carried out on the basis of geometric conversion (coordinate conversion) of the three-dimensional breast shape by linear conversion and interpolation of the voxel concentration value. More specifically, in the three-dimensional geometric conversion by linear conversion, first, the current three-dimensional breast region is tetrahedrally divided. Here, a reference point, which is a vertex of the tetrahedron, can be set at an appropriate position on the breast surface based on the mammilla and an arbitrary position on the base plane of the breast considered as having no deformation, and a multi-divided tetrahedron is formed between the reference point on the breast surface and the reference point on the breast base plane. And the past three-dimensional breast region is analyzed, and a position on the current breast surface corresponding to each reference point on the past breast surface is acquired and set as a transfer point. The transfer point can be obtained from a distance and a direction based on the mammilla by considering that deformation of the breast is deformation in a radial direction around the mammilla surface. Since the tetrahedron to be deformed is determined by the transfer point set as above and the reference point on the base plane of the breast considered as having no deformation, each of the tetrahedrons to be deformed is geometrically converted to a tetrahedral shape of the current breast.

[0057] Here, the breast surface is divided into triangular planes by a plurality of reference points. Therefore, the larger the number of triangular planes is, the smoother surface is formed, and the number is preferably at least 20 or more. On the other hand, the number of reference points on the breast base plane may be approximately several since no deformation is caused at the breast base. Also, the base plane of the past breast is set at a position matching the current breast in a volume of the breast region, but if there is a displacement in the base plane (Z direction) or if there is a displacement between the past and current breast images in the body axis direction (Y direction) or the body width direction (x direction) based on the mammilla, affine conversion, which is linear deformation added with parallel transfer, can be applied.

[0058] The interpolation of the voxel concentration value can be carried out by any of well-known methods such as a nearest neighbor interpolation, bi-linear (linear) interpolation, bi-cubic interpolation, cubic convolution interpolation and the like. However, in the case of this embodiment, the nearest neighbor interpolation (three-dimensional) in which a voxel concentration value closest to the voxel to be interpolated is interpolated is suitable since the processing is the simplest and the voxel concentration value of the past image is not destroyed.

[0059] The past three-dimensional breast image obtained by non-rigid deformation of the past image by the breast voxel data changing device **40** matches the current three-dimensional breast image in the coordinates based on the mammilla. Thus, the past breast tomogram of the cross-sectional spot corresponding to the current breast tomogram can be immediately taken out. However, the past breast tomogram is partially compressed or expanded, and attention should be

paid to the fact that the past breast tomogram is not correctly represented in a precise sense.

[0060] If the breast voxel data changing device **40** is provided, even if an unignorable difference is caused between the current and past images in the entire shape due to change of the shape retaining condition and the like, by carrying out the non-rigid deformation processing so that the entire shape of the past breast matches the current shape, the entire shape can be approximated to the current one. Also, the past tomogram to be displayed by the display device used for interpretation of images **30** immediately corresponds to the current tomogram in terms of coordinates as well, and the corresponding cross-sectional spot can be specified easily in the display device used for interpretation of images **30**.

[0061] The lesion portion automatic detecting/marking device **50** analyzes the voxel data of the breast with computer, automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlapped with the image and is integrated with the display device used for interpretation of images **30** in this embodiment.

[0062] FIG. **7** is a flowchart for automatic detection of a lesion portion positive candidate. As shown in FIG. **7**, the lesion portion automatic detection includes a data input step S**1**, a pre-processing step S**2**, an extraction step S**3** of a search region (breast region), a detection step S**4** of tumor positive candidate, an expansion/contraction processing and labeling processing step S**5**, an adjustment step S**6** of positive candidate, and a data output step S**7**.

[0063] At Step S**1**, the voxel data of the breast is inputted. The inputted data is temporarily recorded in an appropriate buffer and stored during image diagnosis of the subject. In this voxel data, a position of the mammilla (mammilla center) has been acquired in advance.

[0064] Then, in the pre-processing step S**2**, a smoothing filter of 5×5×5 is applied to the voxel data for "noise removal". In an embodiment, saturation of a bright region and a dark region of an image is avoided using a fuzzy enhancement method. In addition, a speckle in the image can be removed using multiscale morphology.

[0065] At the search region extraction step S**3**, a region range (breast region) for detecting a tumor is extracted and determined. The breast surface (or a thin film in close contact with the surface) is represented as a continuous layer of a high echo. The pectoral muscle is visualized as a layer structure of a large quantity of (parallel) high echo and low echo substantially along the body. A method of detecting them includes three-dimensional differentiation filter, Sobel filter (weighted differentiation filter), Laplacian filter (secondary differentiation filter) (edge detection), local pattern matching, concentration gradient vector, binarization and the like. The breast region where a tumor is to be detected shall be a range in the rear of the breast surface and in front of the pectoral muscle.

[0066] At the tumor positive candidate detection step S**4**, the extracted breast region is searched for detecting a tumor. The first step in this detection is binarization processing. Since the tumor is represented as a shade with an echo lower than the periphery, a voxel (pixel) value of the tumor is set as a threshold value and the voxels below and exceeding the value are binarized.

[0067] Here, if the threshold value is too large, the number of false positive candidates is increased. On the contrary, if the value is too small, a true positive candidate might not be detected. Thus, the threshold value should be determined appropriately, but an image quality of a tomogram of a breast is different depending on the person or the age even if an imaging condition is the same. Thus, in this embodiment, a desired value can be selected as the threshold value on the basis of determination by a doctor. Thereby, a numerical balance between true positive and false positive can be set to the most suitable condition for the doctor. The plurality of threshold values offered for the selection can be a plurality of or continuous fixed threshold values examined and determined in advance or may be threshold values in some stages automatically created by obtaining a histogram of normal appropriate regions in the breast image and using information obtained from that in some way. Levels of the arbitrary threshold values from level **1** to level **5**, for example, are selectably displayed on the screen.

[0068] Contraction processing in the expansion/contraction processing step S**5** is processing of converting a black pixel having a white pixel in the vicinity to a white pixel for all the pixels (voxels). The expansion processing is processing of converting a white pixel having a black pixel in the vicinity to a black pixel by reversing the definition of the vicinity. That is because the binarized image includes a macular point in a normal tissue other than a tumor candidate portion. The expansion and contraction processing is repeated appropriately, and a tumor which has become a mass is extracted. The labeling processing is applied to that so as to discriminate each tumor candidate.

[0069] The positive candidate adjustment step S**6** finally determines a mass larger than a predetermined size (4 to 6 mm in general) such as 5 mm or more, for example, as a positive candidate. In this detection, the voxel number of each labeled candidate region is acquired and if it is not less than a predetermined value, it is determined as a positive candidate. Alternatively, a minimum diameter of each candidate region is acquired from a coordinate value and if it is not less than 5 mm, for example, it is determined as a positive candidate. Moreover, the detection can be also made by mapping using a 5 mm-cube or -ball as a search box. The region with a low or no echo in the rear of the mammilla is extracted as a tumor candidate region all the time in this flow method, but that can be excluded at this stage. Finally, at the data output step S**7**, the extracted and determined positive candidate region (tumor) is stored with the coordinates and the data is outputted when the tomogram is displayed later.

[0070] A positive candidate marking portion of the lesion portion automatic detecting/marking device **50** gives an indication mark indicating the positive candidate in superposition on the image on the basis of data relating to the position (coordinates) and range (size) of the positive candidate. FIG. **8** shows a tomogram formed as above, and an indication mark **102** is constituted in a form of an "arrow" as shown. This indication mark can be in any other arbitrary form such as an oval surrounding the positive candidate with an appropriate distance but in any form, its shape and arrangement should be given consideration so that the positive candidate can be surely indicated and the mark does not interfere with diagnosis itself of the positive candidate.

[0071] The CAD display of "ON" and "OFF" by the lesion portion automatic detecting/marking device **50** can be appropriately selected by an examiner such as a doctor and the like by clicking on CAD "ON" on the operation panel window. If the "ON" state of the CAD display is selected, first, the positive candidates of the tumor detected by the lesion portion automatic detecting/marking device **50** are all displayed by

dots at applicable spots of a body mark of a breast (at least either of a half-moon-shaped side face mark and a circular plane mark). That is, in the illustrated embodiment, a "CAD" window portion is provided, in which a circular breast mark is displayed, and the positive candidates of the tumor are indicated by dots within this mark. As the breast mark displaying all the positive candidates in a list, use of a breast mark for position display of the cross section is possible.

[0072] A second possible way is to display the indication mark **102** indicating the detected positive candidate on the breast tomograms displayed in parallel in superposition. This "positive candidate indication mark" is, as mentioned above, typically an arrow or a surrounding line. They are displayed sufficiently away from the positive candidate region or sufficiently proximate for indication of the region. The display of the indication mark **102** shall be selectable considering that the mark can be even confusing for some doctors.

[0073] That is, in the case of primary screening, the most serious burden for doctors is to prevent oversight of a lesion portion for the first place. In this regard, according to the lesion portion automatic detecting/marking device **50** in this embodiment, any suspicious shade as a lesion portion is indicated as a positive candidate as mentioned above, and the doctors can effectively use the information. Also, though lesion portion detection accuracy by the lesion portion automatic detecting/marking device **50** can not be perfect, the doctors can pay attention only to the shades that can not be detected by the lesion portion automatic detecting/marking device **50**, considering the characteristics or features. This will extremely alleviate the burden on the doctors. As mentioned above, according to the ultrasound breast diagnostic system **100** of this embodiment, the burden on the doctor in image diagnosis can be minimized, by which capabilities of the doctor can be maximized.

[0074] The ultrasound breast diagnostic system **100** of this embodiment described above is particularly suitable for primary screening of breast cancer. That is, a quantity of the ultrasound tomograms collected by the ultrasound breast image pickup device **10** becomes enormous if the number of subjects is large, which is a serious burden on doctors who diagnose the images. Moreover, the interpretation of images of sequentially displayed tomograms intensifies the burden. However, according to the ultrasound breast diagnostic system **100** of this embodiment, the corresponding past tomograms are displayed as reference images in parallel with the current breast tomograms to be diagnosed which are sequentially displayed. Thus, since the presence of a lesion portion as an abnormal shade can be diagnosed on the basis of a difference or change between the current image and the past image in the tomograms, accurate diagnosis can be made more easily. That is, even for the ultrasound image in which the interpretation of images itself is not easy and the number of images to be interpreted is large, a burden on a doctor in interpretation of images can be minimized.

[0075] The best mode of the ultrasound breast diagnostic system **100** has been described above, but the present invention is not limited to the configuration described in the above embodiment but the configuration can be changed as appropriate in a range not departing from its gist.

[0076] For example, a comprehensive database for recording and storing the obtained ultrasound tomogram data may be constructed and a network using LAN and the like may be formed with an interpretation of images division. Thereby, doctors can perform the interpretation of images with the past ultrasound tomogram data of the subject or interpretation results by means of mammography.

BRIEF DESCRIPTION OF DRAWINGS

[0077] FIG. **1** is an explanatory diagram illustrating an outline system configuration of an entire ultrasound breast diagnostic system of an embodiment of the present invention.

[0078] FIG. **2** is an explanatory diagram illustrating an outline configuration of an ultrasound breast image pickup device of the embodiment.

[0079] FIG. **3** is an explanatory diagram illustrating a mechanical scanning path of an ultrasound probe of the embodiment.

[0080] FIG. **4** is a diagram illustrating a hardware configuration diagram of an display device used for interpretation of images and its display screen of the embodiment.

[0081] FIG. **5** is a diagram illustrating an example of another display screen of the display device used for interpretation of images.

[0082] FIG. **6** is a diagram illustrating an example of 3D display.

[0083] FIG. **7** is a flowchart for automatic detection of a lesion portion positive candidate.

[0084] FIG. **8** is a diagram illustrating the display screen in detection of a lesion portion by a lesion portion automatic detecting/marking device.

REFERENCE NUMERALS

[0085] **10** ultrasound breast image pickup device
[0086] **11** water bath
[0087] **12** ultrasound probe
[0088] **17** monitor
[0089] **18** recording device
[0090] **20** breast voxel data creating device
[0091] **30** display device used for interpretation of images
[0092] **40** voxel data changing device
[0093] **50** lesion portion automatic detecting/marking device
[0094] **100** ultrasound breast diagnostic system

1. An ultrasound breast diagnostic system comprising:
an ultrasound breast image pickup device provided with a water bath in which a breast can be immersed downward and an ultrasound probe arranged at a bottom portion of the water bath, capable of performing mechanical scanning, for imaging an entire region of a breast in a three-dimensional manner through transmission/reception of an ultrasound wave;
a breast voxel data creating device for creating voxel data of the entire breast on the basis of image data obtained by the ultrasound breast image pickup device; and
an display device used for interpretation of images for displaying an image for image diagnosis on the basis of current and past voxel data of a breast of the same subject created by the breast voxel data creating device in which tomograms in a predetermined direction of the current breast to be diagnosed are sequentially displayed with a predetermined pitch from one end side to the other end side and the past tomogram of a cross-sectional spot corresponding to the tomogram is displayed in parallel.

2. The ultrasound breast diagnostic system according to claim **1**, wherein the breast tomogram is made up of a coronal image.

3. The ultrasound breast diagnostic system according to claim 1, wherein the breast tomogram is made up of either of a sagittal image and an axial image and the current and past tomograms are displayed adjacently and symmetrically with breast base sides abutting each other.

4. The ultrasound breast diagnostic system according to claim 1, wherein the past tomogram of a cross-sectional spot corresponding to the current tomogram is made up of a tomogram of the same cross-sectional spot using a mammilla as a reference point.

5. The ultrasound breast diagnostic system according to claim 2, wherein the past tomogram of a cross-sectional spot corresponding to the current tomogram is made up of a tomogram of the same cross-sectional spot using a mammilla as a reference point.

6. The ultrasound breast diagnostic system according to claim 3, wherein the past tomogram of a cross-sectional spot corresponding to the current tomogram is made up of a tomogram of the same cross-sectional spot using a mammilla as a reference point.

7. The ultrasound breast diagnostic system according to claim 1, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

8. The ultrasound breast diagnostic system according to claim 2, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

9. The ultrasound breast diagnostic system according to claim 3, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

10. The ultrasound breast diagnostic system according to claim 4, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

11. The ultrasound breast diagnostic system according to claim 5, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

12. The ultrasound breast diagnostic system according to claim 6, further comprising a past breast voxel data changing device that carries out non-rigid deformation processing so that an entire shape of the past breast matches the current shape.

13. The ultrasound breast diagnostic system according to claim 1, further comprising a lesion portion automatic detecting/marking device that analyzes the breast voxel data with computer and automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image.

14. The ultrasound breast diagnostic system according to claim 2, further comprising a lesion portion automatic detecting/marking device that analyzes the breast voxel data with computer and automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image.

15. The ultrasound breast diagnostic system according to claim 3, further comprising a lesion portion automatic detecting/marking device that analyzes the breast voxel data with computer and automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image.

16. The ultrasound breast diagnostic system according to claim 4, further comprising a lesion portion automatic detecting/marking device that analyzes the breast voxel data with computer and automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image.

17. The ultrasound breast diagnostic system according to claim 7, further comprising a lesion portion automatic detecting/marking device that analyzes the breast voxel data with computer and automatically detects a lesion portion as a positive candidate and displays a mark indicating the positive candidate overlaid on the image.

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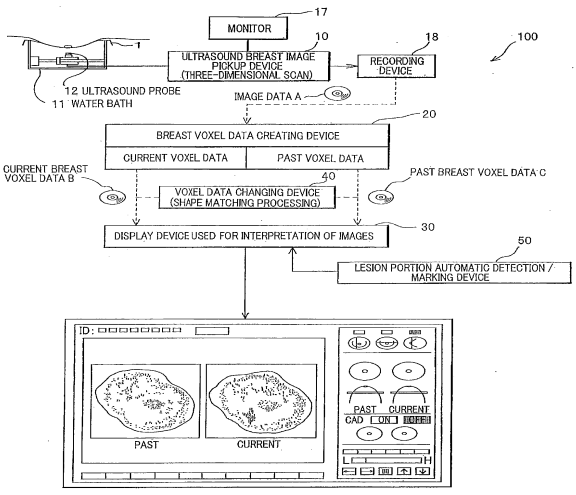
摘要(译)

提供适用于筛查乳腺癌的超声乳房诊断系统，并最小化医生检查所捕获图像的负担。超声乳房诊断系统包括具有水浴的超声乳房成像设备，左乳房和右乳房可以向下浸入，并且超声探头设置在水浴的底部以机械扫描并适于三维地成像整个通过超声波的发送/接收来进行乳房区域，用于从由该装置获取的图像数据在整个乳房上创建体素数据的乳房体素数据创建装置，以及用于解释用于显示用于检查的图像的图像的显示装置过去的体素数据和由设备创建的同一对象的乳房上的当前体素数据。