US 20180333138A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2018/0333138 A1
(43) Pub. Date: Nov. 22, 2018
OKUMURA et al.

(54) ULTRASONIC DIAGNOSTIC APPARATUS, AND ULTRASONIC DIAGNOSTIC METHOD

(71) Applicant: **Canon Medical Systems Corporation**, Otawara-shi (JP)

(72) Inventors: **Takatoshi OKUMURA**, Yaita (JP); **Kazutoshi SADAMITSU**, Otawara (JP); **Yuhei FUKUO**, Nasushiobara (JP); **Norihisa KIKUCHI**, Otawara (JP); **Masatoshi NISHINO**, Otawara (JP); **Yoshinori GOTO**, Nasushiobara (JP); **Naoki YONEYAMA**, Yaita (JP)

(73) Assignee: **Canon Medical Systems Corporation**, Otawara-shi (JP)

(21) Appl. No.: **15/980,173**

(22) Filed: **May 15, 2018**

(30) **Foreign Application Priority Data**

May 16, 2017 (JP) 2017-097110

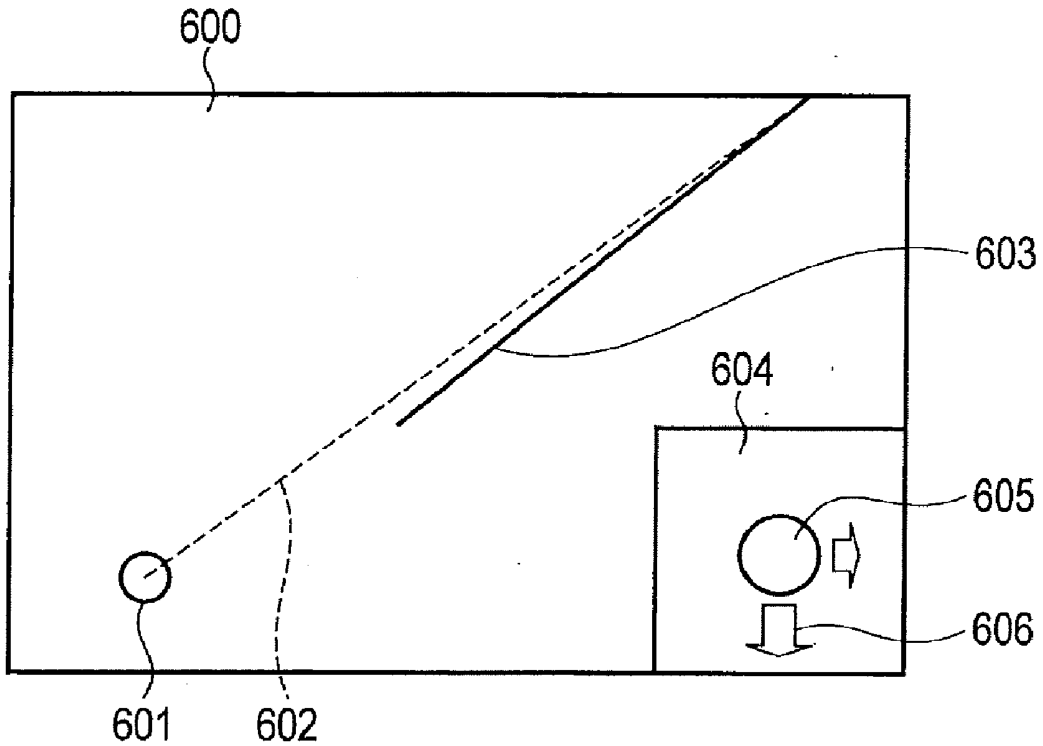
Publication Classification

(51) **Int. Cl.**
A61B 8/00 (2006.01)
A61B 8/08 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 8/463*** (2013.01); ***A61B 8/54*** (2013.01); *A61B 8/4254* (2013.01); *A61B 2562/0247* (2013.01); ***A61B 8/085*** (2013.01)

(57) **ABSTRACT**

According to one embodiment, an ultrasonic diagnostic apparatus includes a processor. The processor generates assistance information to assist an operation of a puncture needle based on pressure information acquired from a pressure sensor attached to the puncture needle. The processor displays on a display the assistance information and an ultrasonic image which includes at least an image of a tip of the puncture needle, the ultrasonic image being acquired by transmission and reception of ultrasonic waves by using an ultrasonic probe.



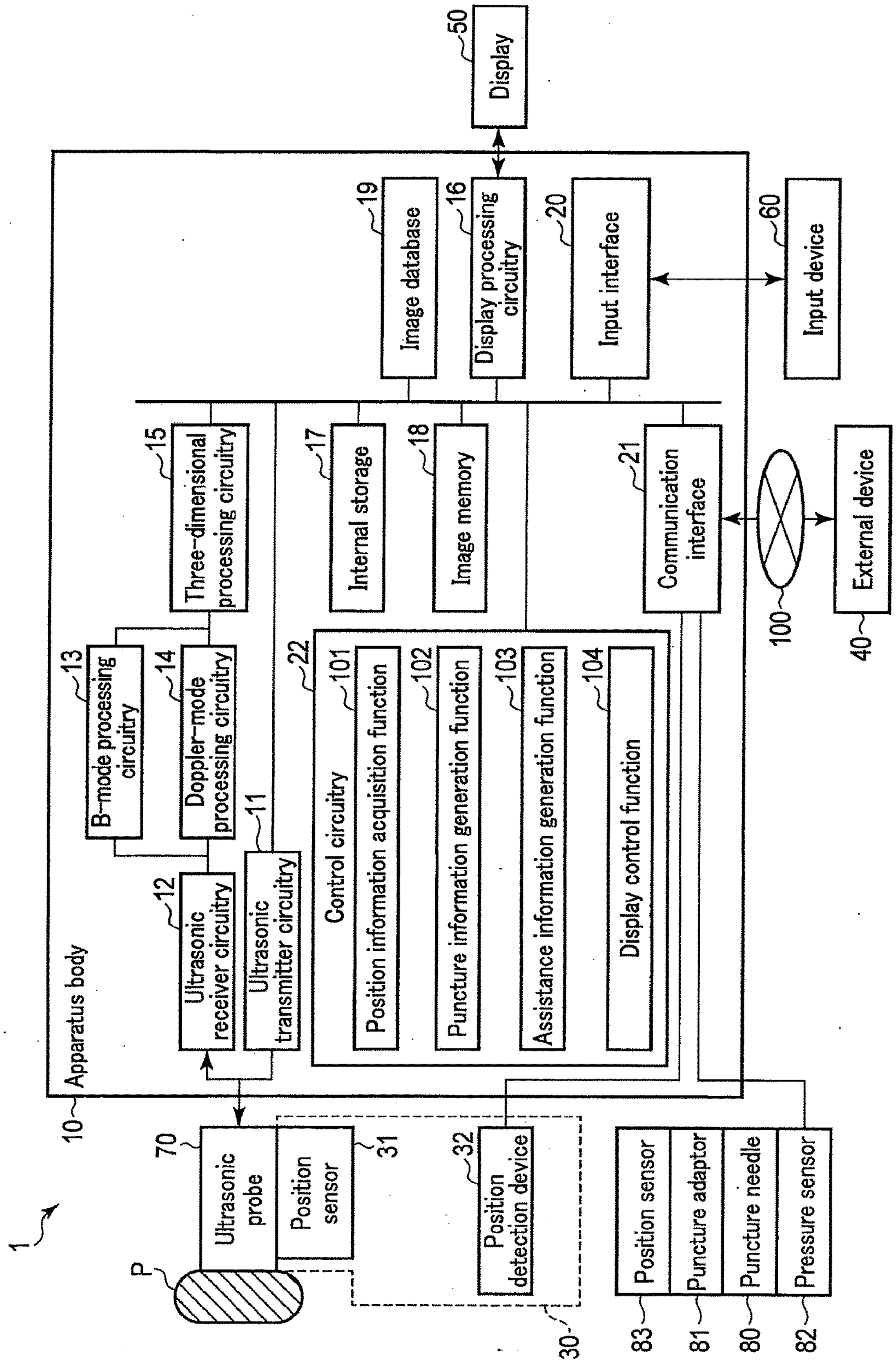
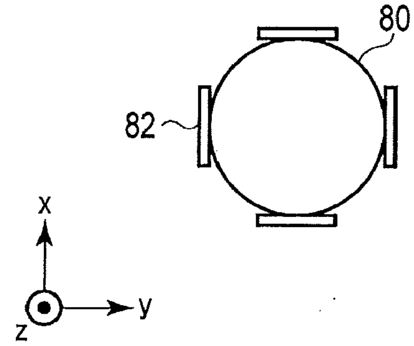
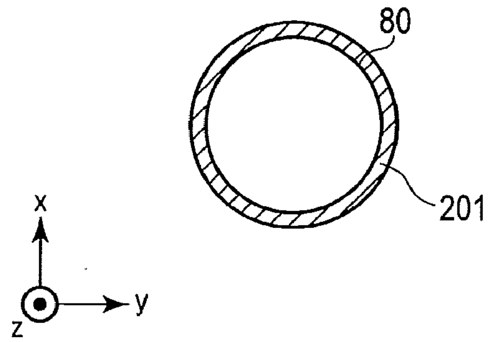

1
10
Apparatus body
11
Ultrasonic transmitter circuitry
12
Ultrasonic receiver circuitry
13
B-mode processing circuitry
14
Doppler-mode processing circuitry
15
Three-dimensional processing circuitry
16
Display processing circuitry
17
Internal storage
18
Image memory
19
Image database
20
Input interface
21
Communication interface
22
Control circuitry
101
Position information acquisition function
102
Puncture information generation function
103
Assistance information generation function
104
Display control function
50
Display
60
Input device
100
40
External device
70
Ultrasonic probe
31
Position sensor
32
Position detection device
30
P
83
Position sensor
81
Puncture adaptor
80
Puncture needle
82
Pressure sensor

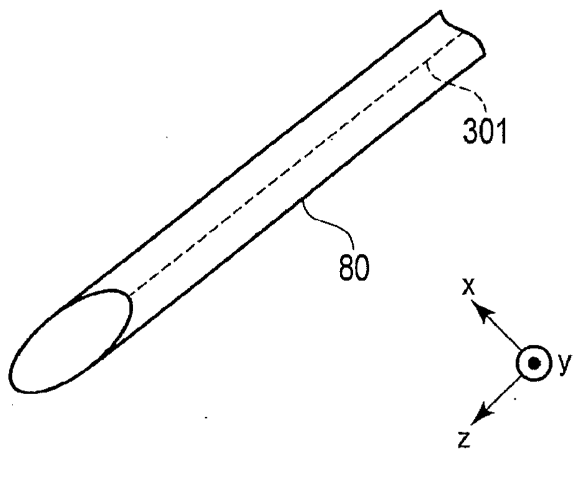
FIG. 1



F I G. 2A



F I G. 2B



F I G. 3

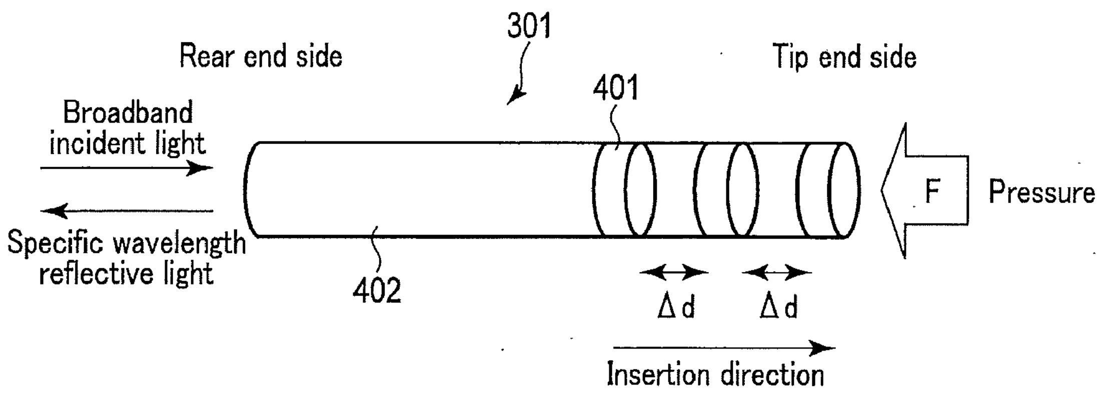

301
Rear end side
Tip end side
401
Broadband incident light
Specific wavelength reflective light
402
F
Pressure
Δd
Δd
Insertion direction

FIG. 4

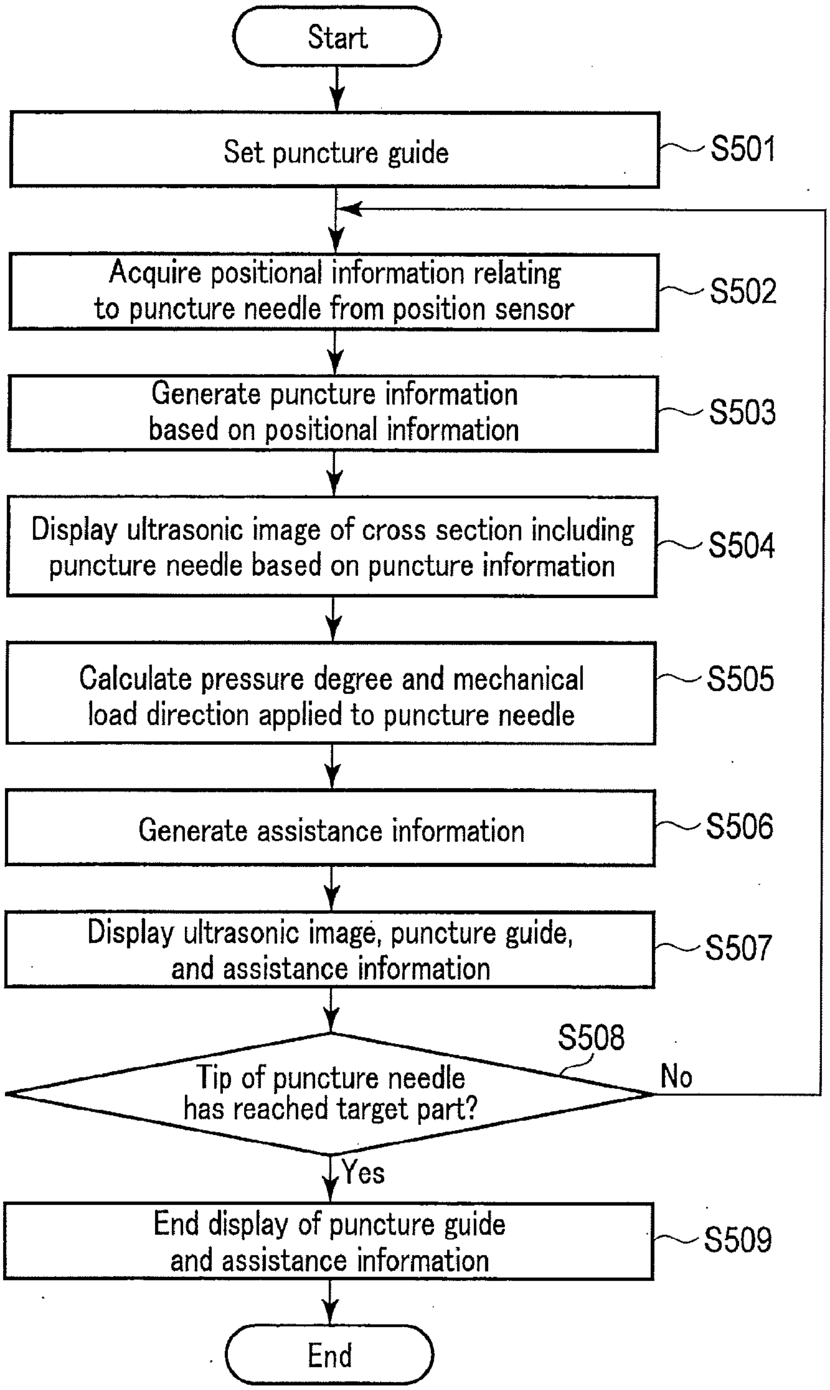

Start
Set puncture guide
S501
Acquire positional information relating to puncture needle from position sensor
S502
Generate puncture information based on positional information
S503
Display ultrasonic image of cross section including puncture needle based on puncture information
S504
Calculate pressure degree and mechanical load direction applied to puncture needle
S505
Generate assistance information
S506
Display ultrasonic image, puncture guide, and assistance information
S507
S508
Tip of puncture needle has reached target part?
No
Yes
End display of puncture guide and assistance information
S509
End

FIG. 5

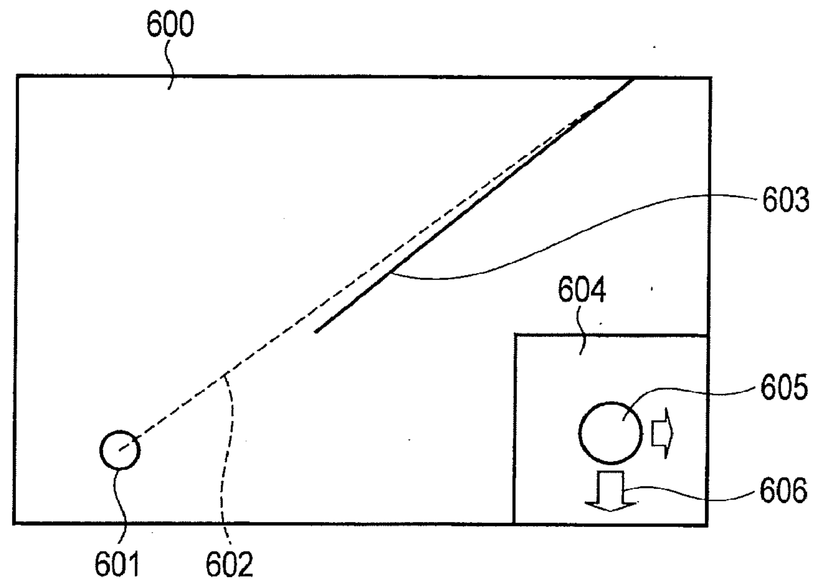


FIG. 6

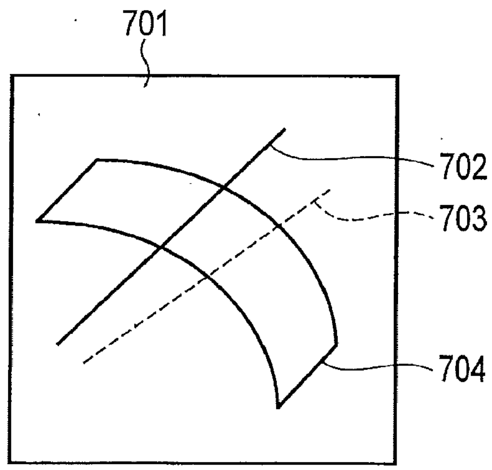


FIG. 7

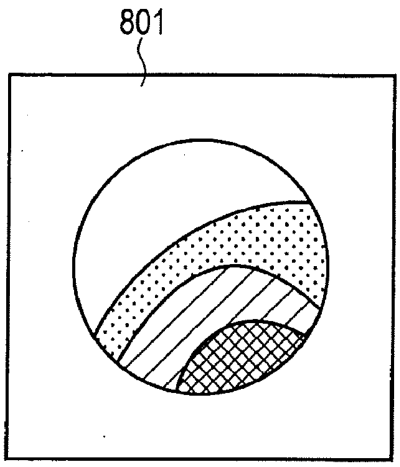


FIG. 8

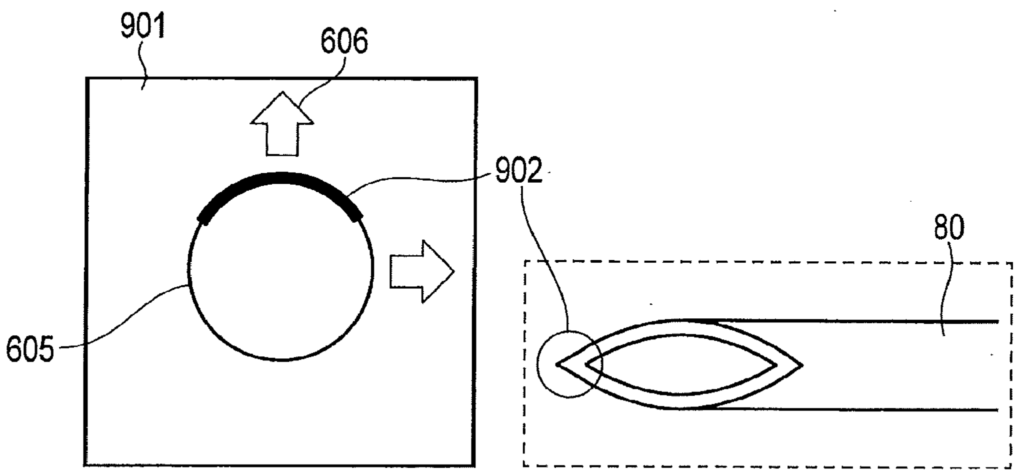
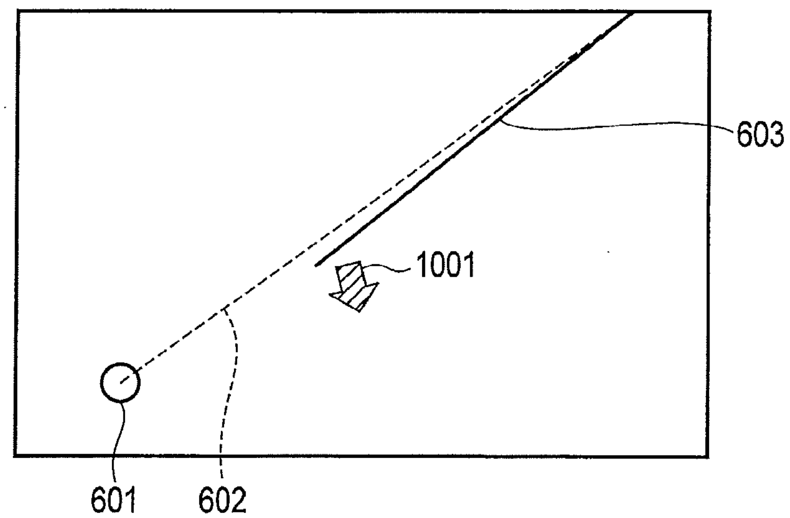


FIG. 9



F I G. 10

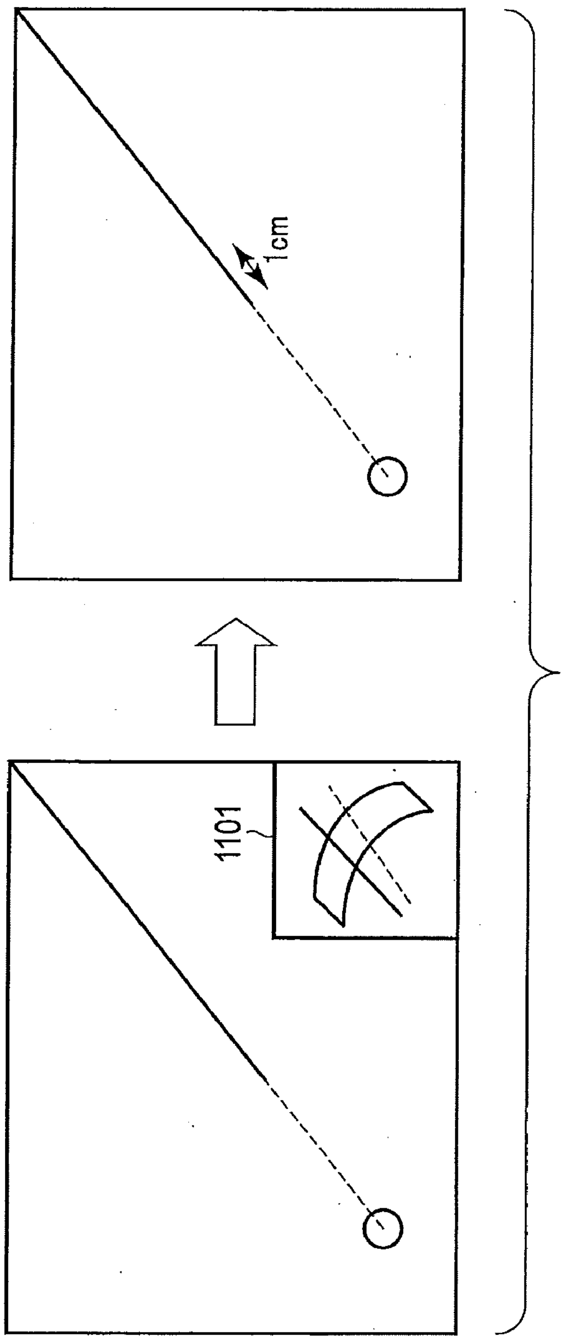
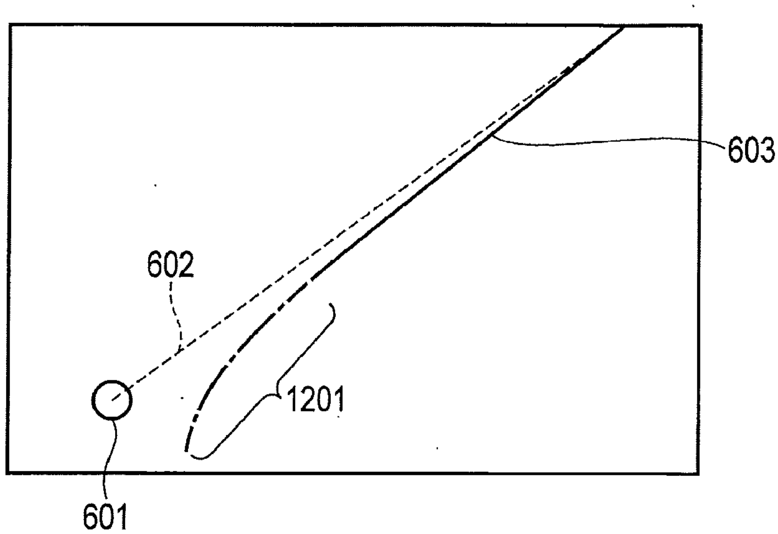
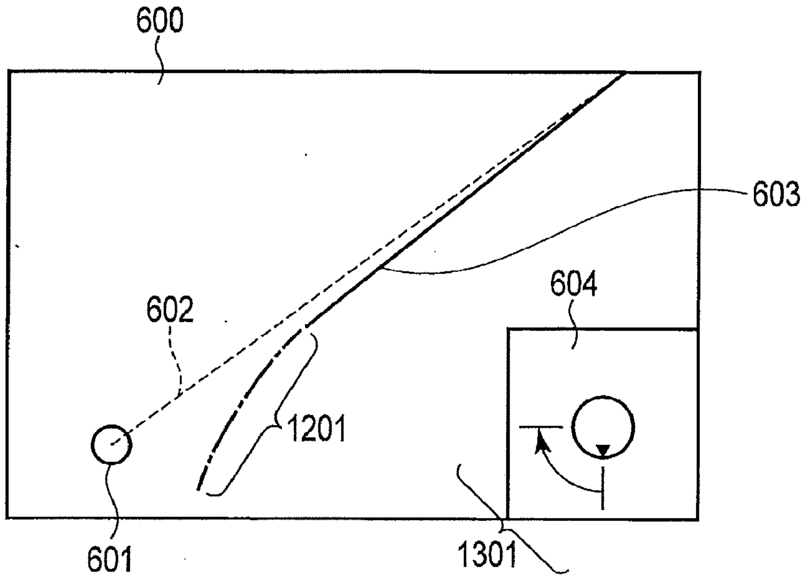


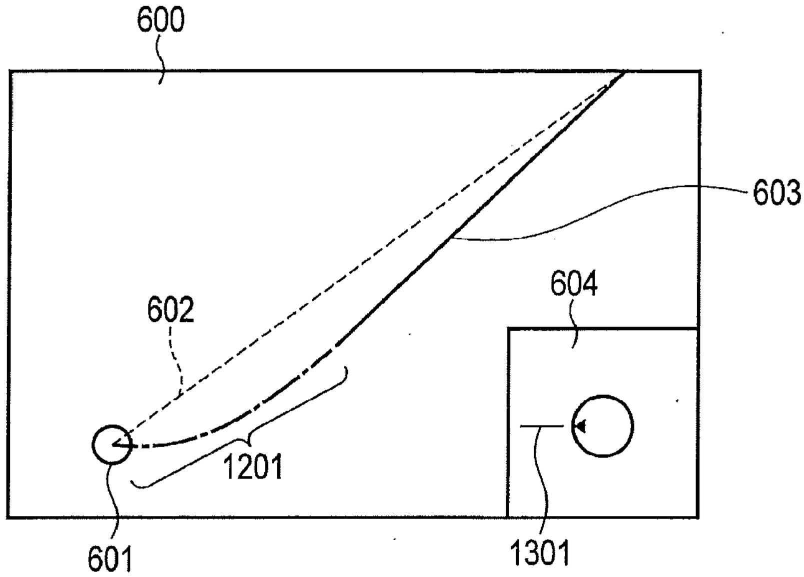
FIG. 11



F I G. 12



F I G. 13



F I G. 14

ULTRASONIC DIAGNOSTIC APPARATUS, AND ULTRASONIC DIAGNOSTIC METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2017-097110, filed May 16, 2017, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate generally to an ultrasonic diagnostic apparatus, and an ultrasonic diagnostic method.

BACKGROUND

[0003] A method of performing a predetermined inspection or diagnosis by inserting a puncture needle into a region of interest (ROI) such as a tumor of a patient (an inspection/diagnosis target) while observing an image obtained by an ultrasonic diagnostic apparatus has been developed. For example, while a two-dimensional image acquired in cross sections that include a puncture needle is displayed, an operator observes a tumor and the puncture needle, and inserts the puncture needle into the tumor based on the displayed positional relationships between them. For the purpose of assisting accurate insertion of a puncture needle, a puncture guide is superimposed to the two-dimensional image. The puncture guide is an indication of an expected insertion path of a puncture needle.

[0004] It is premised that a puncture needle is linearly inserted into a body of a patient. However, a general puncture needle does not have sufficient hardness. Thus, if elasticity (hardness) of a vital tissue on the insertion path is nonuniform, there may be a case where the puncture needle is inserted in a direction deviated from the expected insertion path indicated by the puncture guide.

[0005] To address this problem, there are methods for displaying a position of a puncture needle in which a tip of the puncture needle is displayed based on a three-dimensional image data (volume data), or for displaying an indicator of an estimated position of the puncture needle corrected based on a difference between the indicator and an actual position of the puncture needle on a two-dimensional image.

[0006] An operator needs to correct an insertion direction of a needle tip by predicting a deviation from the puncture guide so that the puncture needle is inserted along the puncture guide. However, if the insertion direction of the puncture needle is deviated from the puncture guide, it is difficult to determine how to correct the insertion direction based only on recognition of the tip of the puncture needle or an image showing the actual position of the puncture needle. Accordingly, the correction of the insertion direction of the puncture needle may rely on the operator's expertise or experiences. As a result, there is a problem that the puncturing accuracy varies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a block diagram showing the configuration of an ultrasonic diagnostic apparatus according to a first embodiment.

[0008] FIG. **2**A illustrates the first example of a pressure sensor attached to a puncture needle.

[0009] FIG. **2**B illustrates the second example of a pressure sensor attached to a puncture needle.

[0010] FIG. **3** illustrates the third example of a pressure sensor attached to a puncture needle.

[0011] FIG. **4** illustrates an operation principle of pressure detection by an optical fiber sensor.

[0012] FIG. **5** is a flowchart of an operation of the ultrasonic diagnostic apparatus.

[0013] FIG. **6** illustrates the first display example of assistance information.

[0014] FIG. **7** illustrates the second display example of assistance information.

[0015] FIG. **8** illustrates the third display example of assistance information.

[0016] FIG. **9** illustrates a display example of a needle tip end position of a puncture needle.

[0017] FIG. **10** illustrates the fourth display example of assistance information.

[0018] FIG. **11** illustrates a display control example of assistance information by a display control function.

[0019] FIG. **12** illustrates a display example of an expected insertion line.

[0020] FIG. **13** illustrates a case where correction information is displayed as assistance information.

[0021] FIG. **14** illustrates a result where a puncture needle is rotated by the amount indicated by correction information.

DETAILED DESCRIPTION

[0022] In general, according to one embodiment, an ultrasonic diagnostic apparatus includes a processor. The processor generates assistance information to assist an operation of a puncture needle based on pressure information acquired from a pressure sensor attached to the puncture needle. The processor displays on a display the assistance information and an ultrasonic image which includes at least an image of a tip of the puncture needle, the ultrasonic image being acquired by transmission and reception of ultrasonic waves by using an ultrasonic probe.

[0023] In the following descriptions, an ultrasonic diagnostic apparatus and an ultrasonic diagnosis method according to the present embodiments will be described with reference to the drawings. In the embodiments described below, elements assigned with the same reference symbols perform the same operations, and redundant descriptions thereof will be omitted as appropriate.

First Embodiment

[0024] An ultrasonic diagnostic apparatus according to the first embodiment will be described with reference to the block diagram shown in FIG. **1**.

[0025] As shown in FIG. **1**, an ultrasonic diagnostic apparatus **1** includes an apparatus body **10**, an ultrasonic probe **70**, and a position sensor system **30**. The apparatus body **10** is connected to an external device **40** through a network **100**. The apparatus body **10** is connected to a display **50** and an input device **60**. The ultrasonic diagnostic apparatus **1** according to the first embodiment is assumed to be used in paracentesis, and the ultrasonic probe **70** and a puncture needle **80** are used together.

[0026] The position sensor system **30** is configured to acquire three-dimensional positional information of the ultrasonic probe **70** and an ultrasonic image. The position sensor system **30** includes a position sensor **31** and a position detection device **32**.

[0027] The position sensor system **30** acquires three-dimensional positional information of the ultrasonic probe **70** by using a magnetic sensor, an infrared sensor, a target for an infrared camera, etc. attached to the ultrasonic probe **70** as the position sensor **31**. A gyro sensor (angular velocity sensor) may be installed in the ultrasonic probe **70** so that the gyro sensor acquires the three-dimensional positional information of the ultrasonic probe **70**. The position sensor system **30** may acquire the three-dimensional positional information of the ultrasonic probe **70** by imaging the ultrasonic probe **70** by a camera and performing image recognition processing to the image of the ultrasonic probe **70**. The position sensor system **30** may detect a three-dimensional position of a robot arm that holds the ultrasonic probe **70** and acquires the position of the robot arm as positional information of the ultrasonic probe **70**.

[0028] An example where the position sensor system **30** acquires the positional information of the ultrasonic probe **70** by using the magnetic sensor will be described below. Specifically, the position sensor system **30** further includes, for example, a magnetic generator (not illustrated) having a magnetic generation coil, etc. The magnetic generator forms a magnetic field oriented outward from the magnetic generator itself. A magnetic space in which location accuracy is assured is defined in the formed magnetic field. The magnetic generator may be arranged so that a living body to be examined is placed within the magnetic space in which location accuracy is assured. The position sensor **31** attached to the ultrasonic probe **70** detects the strength and gradient of a three-dimensional magnetic field formed by the magnetic generator. By this detection, a position and an orientation of the ultrasonic probe **70** can be acquired. The position sensor **31** outputs the detected strength and inclination of the magnetic field to the position detection device **32**.

[0029] The position detection device **32** calculates, for example, a position (a position on a scanning plane (x, y, z) and an rotation angle (θx, θy, θz)) of the ultrasonic probe **70** in the three-dimensional space in which a predetermined position is set to an origin, based on the strength and gradient of the magnetic field detected by the position sensor **31**. The predetermined position is assumed to be, for example, a position where the magnetic generator is placed. The position detection device **32** transmits to the apparatus body **10** positional information relating to the calculated position (x, y, z, θx, θy, θz).

[0030] By associating the acquired positional information with ultrasonic image data obtained by ultrasonic waves transmitted and received relative to the ultrasonic probe **70** by time synchronization, etc., the positional information can be added to the ultrasonic image data.

[0031] The ultrasonic probe **70** includes a plurality of piezoelectric transducers, a matching layer provided to the piezoelectric transducers, and a backing material that prevents propagation of ultrasonic waves to the rear side of the piezoelectric transducers, etc. The ultrasonic probe **70** is detachably connected to the apparatus body **10**. The piezoelectric transducers generate ultrasonic waves based on a driving signal supplied from the ultrasonic transmitter circuitry **11** of the apparatus body **10**. The ultrasonic probe **70** may be provided with a button used for offset processing or in case of freezing of an ultrasonic image, described later.

[0032] Once the ultrasonic probe **70** transmits ultrasonic waves to a living body P, the transmitted ultrasonic waves are sequentially reflected by the boundary showing discontinuity of the acoustic impedance of the living tissue of the living body P, and are received by the plurality of piezoelectric transducers of the ultrasonic probe **70** as reflected wave signals. The amplitude of the received reflected wave signals depends on the difference in the acoustic impedance at the boundary showing discontinuity of the acoustic impedance that affects the reflection of ultrasonic waves. If the transmitted ultrasonic pulses are reflected in a bloodstream or on the surface of the cardiac wall, the frequency of the reflected wave signals is shifted depending on velocity components in the direction of transmitting ultrasonic waves in a moving object due to the Doppler effect. The ultrasonic probe **70** receives the reflected wave signals from the living body P, and converts the reflected wave signals into electrical signals.

[0033] As stated above, since the ultrasonic probe **70** according to the present embodiment is provided with the position sensor **31**, the ultrasonic probe **70** can detect positional information when performing three-dimensional scanning on the living body P. The ultrasonic probe **70** according to the present embodiment is assumed to be able to generate volume data. For example, the ultrasonic probe **70** may be a two-dimensional array type probe in which a plurality of ultrasonic transducers are arranged in a form of a matrix. Alternatively, the ultrasonic probe **70** may be a mechanical four-dimensional probe (mechanical 3D dynamic probe) that includes a one-dimensional array probe and a probe sweeping motor in an enclosure, and mechanically performs a sweep scan or a rotating scan by sweeping the ultrasonic transducers in a predetermined angle (fluctuation angle), and three-dimensionally scans the living body P. In addition, the ultrasonic probe **70** may be a 1.5D array probe in which one-dimensionally arranged transducers are divided into groups.

[0034] The processing of the present embodiment is applicable not only to volume data, but also to the two-dimensional ultrasonic image acquired by a scan in the cross sections including the puncture needle **80**. Accordingly, the ultrasonic probe **70** may be a one-dimensional array probe in which a plurality of ultrasonic transducers are simply arranged in a line in the array direction.

[0035] The ultrasonic probe **70** is provided with a puncture adaptor **81**. The puncture adaptor **81** is capable of defining a puncture initial position of the puncture needle **80**, and of holding the puncture needle **80** slidably relative to the insertion direction. The puncture adaptor **81** can discretionarily adjust the puncture angle of the puncture needle **80**. The puncture needle **80** is inserted into a living body along a scanning surface of ultrasonic waves by using the puncture adaptor **81**. The ultrasonic probe **70** and the puncture adaptor **81** may be separated from each other, and the ultrasonic probe **70** and the puncture needle **80** may be discretionarily operated independently without using the puncture adaptor **81**.

[0036] The puncture needle **80** can be any type of puncture needle. For example, the puncture needle **80** may be a puncture needle for biopsy for the purpose of sampling of a tumor tissue, or a puncture needle for cauterization such as an RFA puncture needle capable of cauterizing a tumor.

[0037] The puncture needle **80** is provided with a pressure sensor **82** and a position sensor **83**. The pressure sensor **82** measures a degree of pressure (a pressure value, for example) applied to the puncture needle **80** at a plurality of positions on the side surface. The position sensor **83** is different from the position sensor **31** provided in the ultrasonic probe **70**. The position sensor **83** measures at least the position of a tip of the puncture needle **80** to obtain positional information of the puncture needle **80**. The position sensor **83** may transmit a radio signal to an external receiver, and the receiver may calculate positional information of the puncture needle **80** based on the radio signal. The position sensor **83** may be a generally used sensor that measures a position of the puncture needle **80**. Accordingly, the detailed explanation is omitted.

[0038] The apparatus body **10** shown in FIG. **1** generates an ultrasonic image, based on reflected wave signals received by the ultrasonic probe **70**. As shown in FIG. **1**, the apparatus body **10** includes ultrasonic transmitter circuitry **11**, ultrasonic receiver circuitry **12**, B-mode processing circuitry **13**, Doppler-mode processing circuitry **14**, three-dimensional processing circuitry **15**, display processing circuitry **16**, an internal storage **17**, an image memory **18** (cine memory), an image database **19**, input interface **20**, communication interface **21**, and control circuitry **22**.

[0039] The ultrasonic transmitter circuitry **11** is a processor that supplies driving signals to the ultrasonic probe **70**. The ultrasonic transmitter circuitry **11** is implemented, for example, by trigger generating circuitry, delay circuitry, and pulser circuitry, etc. The trigger generating circuitry repeatedly generates rate pulses for forming transmission ultrasonic waves at a predetermined rate frequency. The delay circuitry converges ultrasonic waves generated from the ultrasonic probe **70** as a beam, and applies, to each rate pulse generated by the trigger generating circuitry, a transmission delay time for each ultrasonic transducer required for determining a transmission directivity. The pulser circuitry supplies driving signals (driving pulses) to the ultrasonic probe **70** at a timing based on the rate pulse. By changing the transmission delay time to be applied to each rate pulse from the delay circuitry, the transmission direction from the ultrasonic transducer surface can be discretionarily adjusted.

[0040] The ultrasonic receiver circuitry **12** is a processor that executes various processes on reflected wave signals received by the ultrasonic probe **70** to generate a receive signal. The ultrasonic receiver circuitry **12** is implemented, for example, by amplification circuitry, an A/D converter, reception delay circuitry, and an adder, etc. The amplification circuitry executes a gain correction processing for each channel by amplifying reflected wave signals received by the ultrasonic probe **70**. The A/D converter converts the gain-corrected reflected wave signals to digital signals. The reception delay circuitry delays input of the digital signals to an adder by a reception delay time required for determining a reception directivity. The adder adds a plurality of digital signals in which the reception delay time has been applied. After the addition processing of the adder, receive signals are generated in which a reflected component from a direction corresponding to the reception directivity is emphasized.

[0041] The B-mode processing circuitry **13** is a processor that generates B-mode data, based on the receive signals received from the ultrasonic receiver circuitry **12**. The B-mode processing circuitry **13** executes an envelope detection process and a logarithmic amplification process, etc. on the receive signals received from the ultrasonic receiver circuitry **12**, and generates data (B-mode data) in which the signal intensity is expressed by the brightness intensity. The generated B-mode data is stored in a not-illustrated RAW data memory as B-mode RAW data on a two-dimensional ultrasonic scanning line.

[0042] The Doppler-mode processing circuitry **14** is a processor that generates a Doppler waveform and Doppler data, based on the receive signals received from the ultrasonic receiver circuitry **12**. The Doppler-mode processing circuitry **14** extracts a blood flow signal from the receive signal, generates a Doppler waveform from the extracted blood flow signal, and generates data (Doppler data) in which information, such as a mean velocity, dispersion, power, etc. is extracted from the blood flow signal with respect to multiple points.

[0043] The three-dimensional processing circuitry **15** is a processor that can generate volume data along with positional information (three-dimensional image data along with positional information), based on the data generated by the B-mode processing circuitry **13** and the Doppler-mode processing circuitry **14**.

[0044] In addition, the three-dimensional processing circuitry **15** performs, to B-mode RAW data stored in the RAW data memory, RAW-voxel conversion which includes an interpolation process taking spatial position information into consideration to generate volume data consisting of voxels in a desired range. In the case where the ultrasonic probe **70** provided with the position sensor **31** is a mechanical 4D probe (mechanical 3D dynamic probe), or a 2D array probe, positional information calculated by the position detection device **32** is added to volume data.

[0045] Similarly, in the case where the ultrasonic probe **70** provided with the position sensor **31** is a 1D array probe, the three-dimensional processing circuitry **15** adds positional information of the ultrasonic probe **70** calculated by the position detection device **32** to the B-mode RAW data stored in the RAW data memory. Specifically, the three-dimensional processing circuitry **15** executes RAW-voxel conversion to generate two-dimensional image data consisting of pixels, and adds positional information of the ultrasonic probe **70** calculated by the position detection device **32** to the generated two-dimensional image data.

[0046] The three-dimensional processing circuitry **15** generates rendering image data by performing a rendering process to the generated volume data.

[0047] The display processing circuitry **16** executes various processes, such as dynamic range, brightness, contrast and γ curve corrections, and RGB conversion, etc. to image data generated in the three-dimensional processing circuitry **15**, in order to convert the image data to video signals. The display processing circuitry **16** directs the display **50** to display an ultrasonic image in accordance with the video signal. The display processing circuitry **16** may generate a user interface (GUI: Graphical User Interface) through which an operator (for example, a surgeon) inputs various instructions by the input interface **20**, and may direct the display **50** to display the GUI. The display **50** may adopt, for example, a CRT display, a liquid crystal display, an organic EL display, an LED display, a plasma display, or any other displays known in this technical field.

[0048] The internal storage **17** includes, for example, a storage medium which is readable by a processor, such as a magnetic or optical storage medium, or a semiconductor memory, etc. The internal storage **17** stores a control program for implementing ultrasonic transmission/reception, a control program for executing an image process, and a control program for executing a display process, etc. In addition, the internal storage **17** stores diagnosis information (e.g., patient ID, doctor's findings, etc.), a diagnosis protocol, a body mark generation program, and data such as a conversion table for presetting a range of color data for use in visualizing, with respect to each of regions of diagnosis. The internal storage **17** may store anatomical illustrations, for example, an atlas, relating to the structures of internal organs in the body.

[0049] In addition, the internal storage **17** stores two-dimensional image data, volume data, and rendering image data generated by the three-dimensional processing circuitry **15**, in accordance with a storing operation input through the input interface **20**. In accordance with the storing operation input through the input interface **20**, the internal storage **17** may store volume data along with positional information, rendering image data along with positional information, and two-dimensional image data along with positional information, generated by the three-dimensional processing circuitry **15**, together with an operation order and an operation time. The internal storage **17** can transfer the stored data to an external device through the communication interface **21**.

[0050] The image memory **18** includes, for example, a storage medium which is readable by a processor, such as a magnetic or optical storage medium, or a semiconductor memory. The image memory **18** stores image data corresponding to a plurality of frames immediately before a freeze operation input through the input interface **20**. The image data stored in the image memory **18** is successively displayed (cine-displayed), for example.

[0051] The image database **19** stores image data transferred from the external device **40**. For example, the image database **19** acquires and stores past image data relating to a particular patient obtained by the past diagnosis and stored in the external device **40**. The past image data includes ultrasonic image data, computed tomography (CT) image data, MR image data, positron emission tomography (PET)-CT image data, PET-MR image data, and X-ray image data.

[0052] The image database **19** may store desired image data by reading image data stored in a storage medium such as an MO, a CD-R, and a DVD.

[0053] The input interface **20** receives various instructions from an operator through the input device **60**. The input device **60** is, for example, a mouse, a keyboard, a panel switch, a slider switch, a trackball, a rotary encoder, an operation panel, and a touch command screen (TCS). The input interface **20** is connected to the control circuitry **22**, for example, via a bus. The input interface **20** converts an operation instruction input by the operator into electric signals, and outputs the electric signals to the control circuitry **22**. In the present embodiments, the input interface **20** is not limited to be connected to physical operation components such as a mouse, a keyboard, etc. The input interface **20** may include processing circuitry of electric signals which receives, as radio signals, electric signals corresponding to an operation instruction input from an external input device independently provided from the ultrasonic diagnostic apparatus **1**, and outputs the electric signals to the control circuitry **22**.

[0054] The communication interface **21** is, for example, wirelessly connected to the position sensor system **30**, and receives positional information transmitted from the position detection device **32**. The communication interface **21** is connected to the external device **40** through the network **100**, etc., and performs data communication with the external device **40**. The external device **40** is, for example, a database of a picture archiving and communication system (PACS) which is a system for managing various medical image data, a database of an electronic medical record system for managing electronic medical records along with medical images, etc. In addition, the external device **40** may, for example, be any medical image diagnostic apparatus other than the ultrasonic diagnostic apparatus **1** according to the present embodiment, such as an X-ray CT apparatus, an MRI (Magnetic Resonance Imaging) apparatus, a nuclear medical diagnostic apparatus, and an X-ray diagnostic apparatus, etc. Any standards may be applied for communication with the external device **40**. For example, digital imaging and communication in medicine (DICOM) may be applied.

[0055] The control circuitry **22** is a processor acting as a nerve center of the ultrasonic diagnostic apparatus **1**, for example. The control circuitry **22** executes a control program stored in the internal storage to realize a function corresponding to the program. Specifically, the control circuitry **22** activates a position information acquisition function **101**, a puncture information generation function **102**, an assistance information generation function **103**, and a display control function **104**.

[0056] By activating the position information acquisition function **101**, the control circuitry **22** acquires, through the communication interface **21**, positional information relating to the ultrasonic probe **70** from the position sensor system **30**, and positional information relating to the puncture needle **80** from the position sensor **83**.

[0057] By activating the puncture information generation function **102**, the control circuitry **22** generates puncture information relating to at least a position of a tip of the puncture needle **80** and an insertion direction of the puncture needle **80**, based on the sequentially acquired positional information relating to the puncture needle **80**, and the sequentially acquired positional information relating to the ultrasonic probe **70**. By activating the puncture information generation function **102**, the control circuitry **22** generates a puncture guide indicating an expected insertion path to a living body part (target part) such as a tumor to which the puncture needle **80** is to be inserted within a scan area.

[0058] By activating the assistance information generation function **103**, the control circuitry **22** generates assistance information to assist an operation of the puncture needle **80** based on pressure information at a plurality of positions on the puncture needle side surface obtained by the pressure sensors **82**.

[0059] By activating the display control function **104**, the control circuitry **22** controls at least display of the ultrasonic image and the assistance information. For example, the display control function **104** may control the display **50** to display the ultrasonic image of a cross section which includes the puncture needle selected based on the puncture information, the puncture guide and the assistance information. The display control function **104** may output the ultrasonic image, the puncture guide, and the assistance information to the external device **40**, in order for a display, etc. of the external device **40** connected through the network **100** to display them.

[0060] The position information acquisition function **101**, the puncture information generation function **102**, the assistance information generation function **103**, and the display control function **104** may be installed as a control program, or may be installed as a hardware circuit specific to each function in the control circuitry **22** or in the apparatus body **10** in a manner that the control circuitry **22** can refer to the hardware circuit.

[0061] The control circuitry **22** may be implemented by a circuit or a device which includes a hardware circuit specific to these functions such as an application specific integrated circuit (ASIC), an field programmable gate array (FPGA), a complex programmable logic device (CPLD), or an simple programmable logic device (SPLD).

[0062] The first example of the pressure sensor **82** attached to the puncture needle **80** according to the present embodiment will be described with reference to FIG. **2**A.

[0063] FIG. **2**A is a cross-sectional view of the puncture needle **80** from the tip side. Four pressure sensors **82** are provided at the top, bottom, right-side and left-side of the puncture needle **80** in the cross section. With this arrangement, pressure values in four directions from the outside to the inside of the puncture needle can be detected. With the arrangement of the pressure sensors **82** as shown in FIG. **2**A, the control circuitry **22** that activates the assistance information generation function **103** calculates a difference between the pressure values of two pressure sensors **82** facing each other, and calculates a degree of pressure applied to the puncture needle **80** and a direction of a mechanical load applied to the puncture needle **80**. The calculation results indicate that the mechanical load is applied to the puncture needle **80** at the side of the pressure sensor **82** that shows a smaller pressure value. Accordingly, the operator can predict a direction where the puncture needle **80** is to be deviated from the puncture guide (a direction to which the puncture needle **80** may curve).

[0064] The pressure sensor **82** may adopt any sensors capable of measuring a distortion amount such as a piezoelectric element, etc. which is formed of a general semiconductor. The pressure sensors **82** are not limited to be arranged at four points on a circumference of the puncture needle **80**. The number of the pressure sensors **82** may vary. For example, the pressure sensors **82** may be arranged at five or more points of a circumference, or at multiple points on a circumference at predetermined intervals. By adopting multiple pressure sensors **82**, the direction of the mechanical load applied to the puncture needle **80** can be detected more precisely.

[0065] In addition, it is assumed that the pressure sensors **82** are arranged in a range at least within 3 cm from the tip end (insertion side) to the rear end (operator side) of the puncture needle **80**. However, the pressure sensors **82** may be arranged over the entire puncture needle **80**.

[0066] The second example of the pressure sensor **82** attached to the puncture needle **80** according to the present embodiment will be described with reference to FIG. **2**B.

[0067] Instead of arranging the individual pressure sensors at multiple points, a distortion sensor **201** may be wound around the puncture needle **80** to form the pressure sensor **82**. The distortion sensor **201** may be formed of a metallic thin film, etc. mounted to a surface of the puncture needle **80**. By using the principle regarding an electric resistance distortion, the distortion sensor **201** can detect a potential difference from a resistance value at a time when a distortion (deflection, curvature) occurs, and can calculate a pressure value from the detected potential difference. With this structure, more specific information on the direction of the mechanical load applied to the puncture needle **80** can be acquired.

[0068] The distortion sensor formed of a thin film may be wound in a range at least within 3 cm from the tip end to the rear end of the puncture needle **80**, or may be wound over the entire puncture needle **80**, similar to the pressure sensors individually arranged at multiple points. If the distortion sensor is wound over the entire puncture needle **80**, a degree of distortion of the entire puncture needle **80** (a degree of deviation of the entire puncture needle **80** from the puncture guide) can be detected, and this enables easier prediction of the direction of deviation from the puncture guide.

[0069] The third example of the pressure sensor **82** attached to the puncture needle **80** will be described with reference to FIGS. **3** and **4**.

[0070] FIG. **3** shows an example of arrangement of an optical fiber sensor **301** which is used as the pressure sensor **82**. As shown in FIG. **3**, the optical fiber sensor **301** extends along a longitudinal direction of the puncture needle **80**. It is desired that the optical fiber sensor **301** is arranged inside of the puncture needle **80**, but the optical fiber sensor **301** may be provided to cover the puncture needle **80**, or provided along the surface of the puncture needle **80**. In the case where the optical fiber sensor **301** can detect both of a pressure value and a direction of pressure, one optical fiber sensor **301** may be sufficient. If the optical fiber sensor **301** can detect only a pressure value, at least four optical fiber sensors **301** are arranged around the puncture needle **80** to face one another, in order to calculate a direction of pressure based on the difference between the pressure values detected by the optical fiber sensors **301** facing each other.

[0071] FIG. **4** is a schematic diagram of an operation principle of pressure detection by the optical fiber sensor **301**. The right side of the diagram indicates the insertion direction. The optical fiber sensor **301** includes a core **401** that propagates light, and a cladding **402** that covers the core **401**. The core **401** is arranged from the tip end at regular intervals d.

[0072] The operation principle to detect pressure by the optical fiber sensor **301** will be described below. Light having a broad wavelength (broadband incident light) enters from a light source (not illustrated) arranged at the rear end side of the optical fiber sensor **301**. In the case where the optical fiber sensor **301** is bent, the intervals between the cores **401** are changed from regular intervals to interval Δd. The broadband incident light returns to the light source side as a reflective light (specific wavelength reflective light) in which a wavelength of a specific band is emphasized proportional to the interval Δd of the cores **401**. The interval Δd is inversely proportional to externally applied pressure F, and accordingly, a pressure value and a direction of pressure can be detected from the specific wavelength reflective light.

[0073] The operation of the ultrasonic diagnostic apparatus **1** according to the first embodiment will be explained with reference to the flowchart of FIG. **5**. It is assumed that the ultrasonic image and the puncture guide are displayed in advance.

[0074] In step S**501**, the control circuitry **22**, by activating the puncture information generation function **102**, sets a puncture guide relative to a target part included in the ultrasonic image. An example method of generating a puncture guide will be described. However, the general method of calculating an expected path of a puncture needle may be applied. The control circuitry **22**, by activating the puncture information generation function **102**, sets a center of the target part as an end of the puncture guide. Next, the control circuitry **22**, by activating the puncture information generation function **102**, determines a straight line extending from the end of the puncture guide and falling within a range of a puncture angle of the puncture needle (within a range of an angle set by the puncture adaptor **81**) as the puncture guide.

[0075] In step S**502**, the control circuitry **22**, by activating the position information acquisition function **101**, acquires positional information relating to a position and a direction of the puncture needle **80** from the position sensor **31** attached to the puncture needle **80**.

[0076] In step S**503**, the control circuitry **22**, by activating the puncture information generation function **102**, generates puncture information of the puncture needle **80** based on the positional information.

[0077] In step S**504**, the control circuitry **22**, by activating the display control function **104**, displays the ultrasonic image of a cross section including the puncture needle based on the puncture information.

[0078] In step S**505**, the control circuitry **22**, by activating the puncture information generation function **102**, calculates a degree of pressure applied to the puncture needle **80** and a direction of the mechanical load applied to the puncture needle **80** based on pressure information acquired from the pressure sensor provided in the puncture needle **80**.

[0079] In step S**506**, the control circuitry **22**, by activating the assistance information generation function **103**, generates assistance information based on the degree of pressure applied to the puncture needle **80** and the direction of the mechanical load applied to the puncture needle **80** calculated in step S**505**. The operator can operate the puncture needle **80** along the puncture guide by referring to the assistance information.

[0080] In step S**507**, the control circuitry **22**, by activating the display control function **104**, displays the ultrasonic image, the puncture guide, and the assistance information.

[0081] In step S**508**, the control circuitry **22**, by activating the puncture information generation function **102**, determines whether or not a tip of the puncture needle **80** reaches the target part. The determination may be performed, for example, by comparing the positional information (for example, coordinates) of the tip end of the puncture needle with coordinates indicating an area of the target part, and determining whether or not the coordinates of the tip end of the puncture needle **80** is included in the area of the target part. If the tip end of the puncture needle **80** reaches the target part, the processing proceeds to step S**509**. If the tip end of the puncture needle **80** does not reach the target part, the processing returns to step S**502**, and repeats steps S**502** to S**508**.

[0082] In step S**509**, the control circuitry **22**, by activating the display control function **104**, ends display of the puncture guide and the assistance information.

[0083] From step S**502** to step S**508**, real time processing is desired, for example, the processing is sequentially performed every one-second. The operation of the ultrasonic diagnostic apparatus **1** according to the present embodiment ends by the above processing.

[0084] Next, the first display example of the assistance information according to the first embodiment will be described with reference to FIG. **6**.

[0085] FIG. **6** illustrates a display example of an ultrasonic image **600** generated based on transmission/reception of ultrasonic waves by using the ultrasonic probe **70**. A tumor **601** which is a target part to which the puncture needle **80** is inserted is displayed on a screen. A puncture guide **602** to guide a puncture needle to reach the tumor **601** is indicated by a broken line. An image indicating a puncture needle (hereinafter referred to as a puncture needle image **603**) is indicated in a solid line. FIG. **6** shows that the puncture needle image **603** is deviated from the puncture guide **602**.

[0086] An axial image **605** of the puncture needle **80** viewed from the rear side of the puncture needle **80** and an arrow **606** indicating the degree of pressure applied to the puncture needle **80** and the direction of the mechanical load applied to the puncture needle **80** are displayed as assistance information **604**. The axial image **605** is a cross sectional view of a tip of the puncture needle **80** in which the pressure sensor **82** is provided (for example, at a point 3 cm from the end). The degree of pressure is proportional to the pressure value, and is represented as a thickness of the arrow **606**. For example, the thickness of the arrow **606** increases as the degree of pressure increases. However, a numerical value of the pressure value may be indicated along with the arrow **606**.

[0087] In FIG. **6**, the two arrows **606** represent the two directions of pressures for which the difference between the values of a pair of pressure sensors **82** facing each other among four pressure sensors **82** has been calculated. It may be possible to indicate the degree of pressure and the direction of pressure with one arrow by calculating the difference between the pressure values between all the pressure sensors **82** in consideration of the arrangement of each pressure sensor. That is, in the example of FIG. **6**, an arrow directed approximately to the right lower direction of the axial image **605** may be displayed.

[0088] The operator can recognize that the mechanical load is applied to the puncture needle **80** in the right lower direction from the operator side by referring to the assistance information **604** as shown in FIG. **6**. The operator therefore can easily realize that the puncture needle **80** tends to be deviated from the puncture guide **602** in the direction where the mechanical load is applied if the puncture needle **80** is inserted as-is. The operator can easily realize how to correct the insertion direction based on the assistance information **604**. The correction of the insertion direction may be performed by withdrawing and inserting the puncture needle **80** again, or turning the tip, for example, by rotating the puncture needle **80** by 180 degrees.

[0089] The assistance information may include information to correct the deviation of the puncture needle from the puncture guide. The second display example of the assistance information will be described with reference to FIG. **7**.

[0090] FIG. **7** illustrates an extract of the assistance information displayed along with the ultrasonic image.

[0091] A puncture angle **702** of the puncture needle, a correction angle **703** of the puncture needle, and a puncture adaptor image **704** are displayed as assistant information **701**. The puncture angle **702** represents an actual insertion angle of the puncture needle **80** and a path of the puncture needle **80**, and is indicated by a solid line. The puncture angle **702** is an angle along the puncture guide, in the initial stage. The puncture angle **702** may be an angle set by the puncture adaptor **81**, for example. A numerical value of an angle may be added along the solid line, or may be indicated instead of the solid line. A correction angle **703** represents an angle of the puncture needle **80** to correct the puncture needle **80** deviated from the puncture guide, and is indicated by a broken line. The correction angle **703** may be indicated by a numerical value of an angle added along the broken line, or may be indicated only by a numerical value of the angle.

[0092] The operator can easily realize the angle of inserting the puncture needle **80** to the living body in order to reach the target part by referring to the assistant information **701** as shown in FIG. **7**. Accordingly, the angle of the puncture needle **80** can be adjusted in accordance with the correction angle **703**, and the puncture needle **80** can be re-inserted at an appropriate angle.

[0093] In addition, as shown in FIG. **8**, the degree of pressure and the direction of pressure applied to the puncture needle **80** may be represented as contour lines or a color map, which is the third display example of the assistance information. Assistance information **801** represents the values of the pressure sensors **82** attached to the puncture needle as they are. By representing the distribution of pressure values as contour lines or a color map as the assistance information **801**, the pressure value and the direction of the mechanical load applied to the puncture needle **80** can be instinctively realized similarly to the case where arrows are used as the assistance information. In the example of FIG. **8**, it is indicated that the pressure is externally applied to the puncture needle **80** from the right lower direction in the cross section. Accordingly, the operator expects that the puncture needle **80** is going to shift (curve) in the left upper direction.

[0094] In addition to the aforementioned display example of the assistance information, information relating to the position of a needle tip end (needle tip end position) of the puncture needle **80** or a blade surface of the puncture needle tip may be displayed. In the present embodiment, the needle tip end is an edge of the puncture needle **80** that is firstly brought into contact with a living body P. A display example in which information on the needle tip end position is added to the assistance information is illustrated in FIG. **9**.

[0095] The puncture needle **80** is generally formed in a manner that a tip end is canted off to form a blade surface and a sharp tip. The direction of inserting the puncture needle **80** is mostly determined by the orientation of the blade surface. Specifically, while the puncture needle **80** is being inserted into the living body, the puncture needle **80** is going to curve to the direction opposed to the blade surface, i.e., the tip of the puncture needle **80** is warped in many cases.

[0096] Accordingly, as shown in FIG. **9**, the needle tip end position **902** of the puncture needle is displayed in addition to the arrow **606** as assistance information **901**. The needle tip end position **902** of the puncture needle can be detected by associating the needle tip end with a predetermined position of a pressure sensor. The operator can recognize the needle tip end position **902** by referring to the assistance information **901**, and can further improve the prediction accuracy of the direction in which the puncture needle is to be deviated from the puncture guide. The needle tip end position **902** is indicated as a solid arc having a predetermined angle range in FIG. **9**. However, the needle tip end position **902** may be indicated by a dot or by coloring a portion corresponding to the tip of the puncture needle **80** among a circle representing an axial image **605**. That is, the needle tip end position **902** may be indicated in any way if the needle tip end position is specified.

[0097] The puncture needle **80** may be displayed as a three-dimensional model so that the operator can recognize the blade surface more easily.

[0098] In the case where the needle tip end position **902** is displayed as the assistance information **901**, an arrow **606** may indicate the direction to which the puncture needle **80** is to be moved to correct the deviation from the puncture guide instead of displaying the direction of pressure applied to the puncture needle **80**.

[0099] As shown in FIG. **10**, assistance information is indicated by an arrow **1001** near the tip of the puncture needle image **603**, instead of displaying the assistance information in a window different from the ultrasonic image. This is the fourth display example of the assistance information. As stated above, the assistance information may be indicated in any aspect if the degree and the direction of the pressure can be recognized.

[0100] According to the aforementioned first embodiment, the degree and the direction of pressure applied to the puncture needle are calculated by the pressure sensors, and the assistance information to assist the operation of the puncture needle is generated. Therefore, a deviation of the puncture needle from the puncture guide can be quantitatively detected, and the operator can easily realize how to correct the deviation from the puncture guide. This configuration can assist accurate puncturing in paracentesis regardless of the puncturing skill of the operator. In particular, this embodiment has advantages in the case of requiring accuracy of puncturing, for example, in the case where a target part is tiny such as early-stage cancer.

Second Embodiment

[0101] In the case where deviation of the puncture needle from the puncture guide is corrected based on the assistance information according to the first embodiment, pressure from the operation is applied to the puncture needle. Accordingly, if the operator is correcting the deviation of the puncture needle at a time when the assistance information is generated, there is a possibility that incorrect assistance information may be generated based on pressure other than the pressure applied due to insertion of the puncture needle into the living body. In this case, the operator may operate the puncture needle incorrectly, based on the incorrect assistance information. There may be a case where real-time assistance information may be annoying for the operator. In the second embodiment, the assistance information can be switched between an on-state and an off-state at predetermined intervals or manually so that assistance information can be suitably generated.

[0102] The ultrasonic diagnostic apparatus according to the second embodiment performs the operations similar to the ultrasonic diagnostic apparatus of the first embodiment except the operation of the display control function **104**.

[0103] The control circuitry **22**, by activating the display control function **104**, switches on and off states of the assistance information display in accordance with the degree of insertion of the puncture needle **80** into a living body. The display of assistance information may be switched as indicated below. For example, in the initial setting, display of assistance information is in the on-state, the display is switched to the off-state for a predetermined time (for example, for three seconds) if the puncture needle is inserted a predetermined distance (for example, 1 cm) into a living body, and after a predetermined time has elapsed, the display is switched to the on-state. On the other hand, the display of assistance information is in the off-state in the initial setting, if the puncture needle inserted a predetermined distance into a living body, the display is switched to the on-state for a predetermined time, and after a predetermined time has elapsed, the display is switched to the off-state. The operator may correct the insertion direction of the puncture needle while the display of assistance information is in the off-state.

[0104] Alternatively, the control circuitry **22**, by activating the display control function **104**, may switch on/off states of the assistance information in response to the operator's instruction.

[0105] An example of display control of the assistance information by the display control function **104** will be explained with reference to FIG. **11**.

[0106] FIG. **11** illustrates the case where display of assistance information is in the on-state in the initial setting. As shown in the left drawing, if the puncture needle is inserted 1 cm in the state where assistance information **1101** is displayed, the display of the assistance information **1101** comes to be in the off-state. The display control function **104** may control the display of the assistance information **1101** to be downsized or to be translucent (increase transparency), instead of completely turning off the display of the assistance information **1101**. That is, the assistance information **1101** may be displayed in any form different from normally displayed assistance information so that the assistance information **1101** can be recognized as the information that the operator should not refer to.

[0107] According to the aforementioned second embodiment, the display of assistance information is switched between on/off states by the display control function so that assistance information generated based on inappropriate information such as pressure applied to the puncture needle from the operator is not displayed, or the form of display is changed by the display control function so that the operator can distinguish the assistance information generated based on inappropriate information. Therefore, updated assistance information can be displayed to the operator at a suitable timing. The operator can reduce the possibility of operating the puncture needle based on incorrect assistance information, and assistance for highly accurate puncturing can be provided.

[0108] It is also possible to display an expected insertion line indicating an expected insertion direction of the puncture needle on the ultrasonic image explained in the aforementioned embodiments.

[0109] A display example of an expected insertion line will be described with reference to FIG. **12**.

[0110] In the example shown in FIG. **12**, the puncture guide **602** is displayed by a broken line, and an expected insertion line **1201** of the puncture needle is displayed by an alternating long and short dashed line on the ultrasonic image. The expected insertion line **1201** is generated as indicated below.

For example, a pressure value applied to the puncture needle and a distortion amount and a distortion direction of the puncture needle (deviation from a geometric extension of the puncture needle without the distortion) are stored as being associated with each other in the internal storage **17**. The control circuitry **22**, by activating the assistance information generation function **103**, generates a path of the expected insertion line **1201** in accordance with the distortion direction and the distortion amount corresponding to the measured pressure value.

[0111] By displaying the expected insertion line **1201**, the operator can easily realize in what degree the puncture needle curves or in what degree the puncture needle is deviated from the tumor **601** or the puncture guide **602** if the puncture needle is inserted as-is. In the case where the puncture guide **602** and the expected insertion line **1201** are displayed at the same time, this information may be differentiated based on at least one of a type of line, a thickness, or a color. Only the expected insertion line **1201** may be displayed without displaying the puncture guide **602**.

[0112] It is also possible to display correction information indicating in what degree the needle tip should be rotated to adjust the path of the puncture needle to reach the tumor **601** as assistance information.

[0113] An example of a case where correction information is displayed as assistance information will be explained with reference to FIGS. **13** and **14**.

[0114] FIG. **13** illustrates an example case where the assistance information **604**, the puncture guide **602**, and the expected insertion line **1201** are displayed on the ultrasonic image **600**. In FIG. **13**, the expected insertion line **1201** shows that the insertion direction of the puncture needle is expected to be away from the tumor **601**.

[0115] Correction information **1301** indicating a correction required for the tip of the puncture needle to reach the tumor **601** is displayed as the assistance information **604**. The correction information **1301** is, for example, information indicating to what degree the puncture needle is required to be rotated (the amount of rotation) in which direction from the current state. In the example of FIG. **13**, the needle tip end position is indicated by a triangle mark, and the rotation amount is indicated by using two bars. FIG. **13** shows that the correction information **1301** indicates that the puncture needle needs to be rotated clockwise by 45 degrees to reach the tumor **601**. By this display, the operator can easily realize how to correct the puncture needle instinctively. In the case where it is difficult for the puncture needle to reach the tumor **601** only by the rotation correction of the puncture needle, information used for correcting an insertion distance of the puncture needle or information indicating that it is necessary to withdraw the puncture needle and reset a puncture initial position is displayed as correction information. The correction information **1301** may be displayed in any way if the operator can understand the indication of the correction information **1301**.

[0116] The correction information **1301** may be obtained, for example, by calculating the rotation direction and the rotation amount of the tip of the puncture needle based on the deviation amount of the expected insertion line **1201** from the extension of the puncture guide **602** and the position of the tumor **601**. The rotation amount may be represented as a numeric value such as "45°" on a screen, or expressed as beeps which are set to be sounded in shorter intervals as the rotation amount becomes closer to the calculated rotation amount.

[0117] The result where the puncture needle is rotated based on the correction information **1301** is illustrated in FIG. **14**.

[0118] As shown in FIG. **14**, as a result where the puncture needle is rotated by the amount indicated by the correction information **1301**, the expected insertion line **1201** is updated to be directed to the tumor **601**.

[0119] While the operator is rotating the puncture needle, the expected insertion line **1201** may be updated in real-time in accordance with the rotated amount. To update the expected insertion line **1201**, the control circuitry **22**, by activating the assistance information generation function **103**, three-dimensionally calculates the expected insertion line **1201** in accordance with the rotation of the puncture needle so that the expected insertion line **1201** is directed to the direction of the needle tip (the needle tip is warped from the extension of the puncture needle), and projects the calculated expected insertion line **1201** on the plane where the ultrasonic image is displayed.

[0120] The functions described in connection with the above embodiments may be implemented, for example, by installing a program for executing the processing in a computer, such as a work station, etc., and expanding the program in a memory. The program that causes the computer to execute the processing can be stored and distributed by means of a storage medium, such as a magnetic disk (a hard disk, etc.), an optical disk (CD-ROM, DVD, Blu-ray® Disc, etc.), and a semiconductor memory.

[0121] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An ultrasonic diagnostic apparatus comprising a processor configured to:

generate assistance information to assist an operation of a puncture needle based on pressure information acquired from a pressure sensor attached to the puncture needle; and

display on a display the assistance information and an ultrasonic image which includes at least an image of a tip of the puncture needle, the ultrasonic image being acquired by transmission and reception of ultrasonic waves by using an ultrasonic probe.

2. The apparatus according to claim **1**, wherein the assistance information includes information relating to a degree of pressure applied to the puncture needle and a direction of a mechanical load applied to the puncture needle.

3. The apparatus according to claim **1**, wherein the processor is further configured to display on the display a puncture guide indicating an expected insertion path of the puncture needle.

4. The apparatus according to claim **3**, wherein the assistance information includes a puncture angle of the puncture needle and a correction angle to correct deviation from the puncture guide.

5. The apparatus according to claim **1**, wherein the processor generates puncture information that includes at least a position of the tip of the puncture needle and a insertion direction of the puncture needle, by using positional information regarding the puncture needle acquired from a position sensor, and

wherein the ultrasonic image is a cross sectional view including the puncture needle and is generated based on the puncture information.

6. The apparatus according to claim **1**, wherein the assistance information includes information regarding a needle tip end position of the puncture needle.

7. The apparatus according to claim **1**, wherein the pressure sensor is formed by one of an optical fiber, a metallic thin film, and a semiconductor.

8. The apparatus according to claim **1**, wherein the processor controls at least one of turning on and off of display of the assistance information and a form of display of the assistance information, in accordance with a degree of insertion of the puncture needle.

9. The apparatus according to claim **1**, wherein the processor displays on the display an expected insertion line indicating an expected insertion path of the puncture needle.

10. The apparatus according to claim **1**, wherein the assistance information includes correction information to correct a path of the puncture needle.

11. An ultrasonic diagnostic method comprising:

generating assistance information to assist an operation of a puncture needle based on pressure information acquired from a pressure sensor attached to the puncture needle; and

displaying on a display the assistance information and an ultrasonic image which includes at least an image of a tip of the puncture needle, the ultrasonic image being acquired by transmission and reception of ultrasonic waves by using an ultrasonic probe.

* * * * *

专利名称(译)	超声诊断设备和超声诊断方法		
公开(公告)号	US20180333138A1	公开(公告)日	2018-11-22
申请号	US15/980173	申请日	2018-05-15
[标]发明人	OKUMURA TAKATOSHI SADAMITSU KAZUTOSHI FUKUO YUHEI KIKUCHI NORIHISA NISHINO MASATOSHI GOTO YOSHINORI YONEYAMA NAOKI		
发明人	OKUMURA, TAKATOSHI SADAMITSU, KAZUTOSHI FUKUO, YUHEI KIKUCHI, NORIHISA NISHINO, MASATOSHI GOTO, YOSHINORI YONEYAMA, NAOKI		
IPC分类号	A61B8/00 A61B8/08		
CPC分类号	A61B8/463 A61B8/54 A61B8/085 A61B2562/0247 A61B8/4254 A61B8/0841 A61B8/4416 A61B8/483 A61B8/488		
优先权	2017097110 2017-05-16 JP		
外部链接	Espacenet USPTO		

摘要(译)

根据一个实施例，超声诊断设备包括处理器。处理器基于从附接到穿刺针的压力传感器获取的压力信息生成辅助信息以辅助穿刺针的操作。处理器在显示器上显示辅助信息和超声图像，该超声图像至少包括穿刺针尖端的图像，超声波图像通过使用超声波探头发送和接收超声波来获取。