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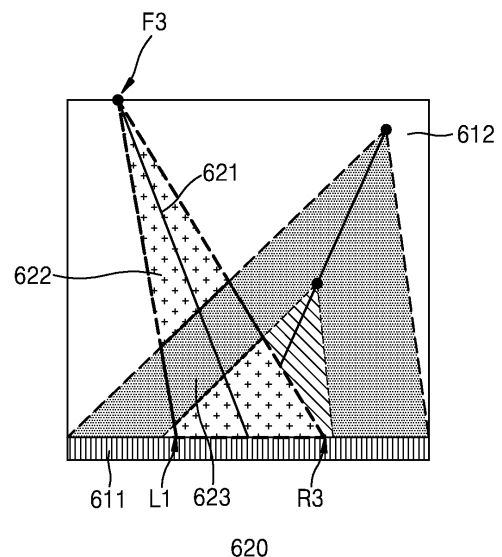
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(54) **ULTRASONIC DEVICE AND OPERATION METHOD THEREFOR**

(57) Provided is an ultrasound imaging apparatus including a probe configured to transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object; and a processor configured to generate a first ultrasound image representing the object, detect at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion, control the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region, and generate a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

FIG. 6B



Description

TECHNICAL FIELD

- 5 **[0001]** The present disclosure relates to ultrasound apparatuses and methods of operating the same, and more particularly, to apparatuses and methods of performing beamforming.

BACKGROUND ART

- 10 **[0002]** Ultrasound diagnosis apparatuses transmit ultrasound signals generated by transducers of a probe to an object and receive echo signals reflected from the object, thereby obtaining an image of an object or an internal part of the object. In particular, ultrasound diagnosis apparatuses are used for medical purposes including observing an internal area of an object, detecting foreign substances, and assessing injuries. Such ultrasound diagnosis apparatuses exhibit high stability, display images in real time, and are safe due to there being no radiation exposure, compared to X-ray apparatuses. Therefore, an ultrasound diagnosis apparatus is widely used together with other types of imaging diagnosis apparatuses.

DISCLOSURE

20 TECHNICAL PROBLEM

[0003] Provided are ultrasound imaging apparatuses and methods of operating the same, whereby a more precise ultrasound image may be obtained by detecting a region having low image quality in an ultrasound image and compensating for the low image quality of the region.

- 25 **[0004]** Provided is a non-transitory computer-readable recording medium having recorded thereon a program for executing a method of operating an ultrasound imaging apparatus on a computer.

TECHNICAL SOLUTION

- 30 **[0005]** According to an aspect of an embodiment, an ultrasound imaging apparatus includes: a probe configured to transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object; and a processor configured to generate a first ultrasound image representing the object, detect at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion, control the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region, and generate a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

[0006] The first path is determined based on information about a position of an origin of an ultrasound beam composed of the ultrasound signal and on information about a transmission direction of the ultrasound beam.

- 40 **[0007]** The probe is further configured to transmit an ultrasound beam composed of the ultrasound signal to the object in a plurality of directions and receive echo signals respectively reflected from the object based on the plurality of directions, and wherein the processor is further configured to detect, according to a predetermined criterion, at least one region having low image quality among regions in the first ultrasound image by using the reflected echo signals.

- 45 **[0008]** When detecting the at least one region having low image quality according to the predetermined criterion, the processor detects, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point as a region having low image quality.

[0009] The ultrasound imaging apparatus further includes a display configured to display at least one of the first and second ultrasound images.

- 50 **[0010]** The display is further configured to display a map indicating quality of the first ultrasound image based on the detected at least one region.

[0011] The display is further configured to display the map in such a manner as to distinguish the at least one region from the other regions excluding the at least one region.

- 55 **[0012]** The probe comprises a transducer array consisting of a plurality of transducers, and the plurality of transducers are arranged in a one-dimensional (1D) or two-dimensional (2D) array.

[0013] The information about the transmission direction of the ultrasound beam is information about an angle between the transmission direction of the ultrasound beam and the transducer array.

[0014] The ultrasound signal is transmitted along the first path while being focused at a first focal point, and the

ultrasound signal is transmitted along the second path while being focused at a second focal point.

[0015] The processor is further configured to control the ultrasound signal to be transmitted along a third path based on the at least one region and generate a second ultrasound image corresponding to the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path and an echo signal received in response to the ultrasound signal transmitted to the object along the third path. The ultrasound imaging apparatus further includes a user interface configured to receive a user input for setting transmission of the ultrasound signal along the second path based on the at least one region, and wherein the processor is further configured to control the ultrasound signal to be transmitted along the second path based on the user input.

[0016] The processor is further configured to control the probe to perform beamforming by using a predetermined number of sub-apertures into which a plurality of transducers in the probe are divided.

[0017] According to an aspect of another embodiment, a method of operating an ultrasound imaging apparatus includes: transmitting an ultrasound signal to an object along a first path and receiving an echo signal reflected from the object; generating a first ultrasound image representing the object and detecting at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion; controlling the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region; and generating a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

[0018] The first path is determined based on information about a position of an origin of an ultrasound beam composed of the ultrasound signal and on information about a transmission direction of the ultrasound beam.

[0019] The transmitting of the ultrasound signal to the object along the first path and the receiving of the echo signal reflected from the object comprises transmitting an ultrasound beam composed of the ultrasound signal to the object in a plurality of directions and receiving echo signals respectively reflected from the object based on the plurality of directions, and wherein the generating of the first ultrasound image and the detecting of the at least one region having low image quality according to the predetermined criterion comprises detecting, according to a predetermined criterion, at least one region having low image quality among regions in the first ultrasound image by using the reflected echo signals.

[0020] The detecting of the at least one region having low image quality according to the predetermined criterion comprises detecting, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point as a region having low image quality.

[0021] The method further includes displaying at least one of the first and second ultrasound images.

[0022] The method further includes displaying a map indicating a quality of the first ultrasound image based on the detected at least one region.

[0023] The displaying of the map indicating the quality of the first ultrasound image comprises displaying the map in such a manner as to distinguish the at least one region from the other regions excluding the at least one region.

[0024] The controlling of the ultrasound signal to be transmitted along the second path comprises controlling the ultrasound signal to be transmitted along a third path based on the at least one region, and wherein the generating of the second ultrasound image representing the object based on the echo signal comprises generating the second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path and an echo signal received in response to the ultrasound signal transmitted to the object along the third path.

[0025] The method further includes receiving a user input for setting transmission of the ultrasound signal along the second path based on the at least one region, wherein the controlling of the ultrasound signal to be transmitted along the second path comprises controlling the ultrasound signal to be transmitted along the second path based on the user input.

[0026] According to an aspect of another embodiment, a non-transitory computer-readable recording medium has recorded thereon a program for executing a method of operating an ultrasound imaging apparatus on a computer, wherein the method includes transmitting an ultrasound signal to an object along a first path and receiving an echo signal reflected from the object; generating a first ultrasound image representing the object and detecting at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion; controlling the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region; and generating a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

ADVANTAGEOUS EFFECTS

[0027] An ultrasound imaging apparatus according to an embodiment may obtain a more precise ultrasound image

by detecting a region having low image quality in an ultrasound image and compensating for the low image quality of the region.

DESCRIPTION OF DRAWINGS

[0028] Embodiments now will be described more fully hereinafter with reference to the accompanying drawings, in which reference numerals denote structural elements:

FIG. 1 is a block diagram of a configuration of an ultrasound diagnosis apparatus according to an embodiment;
 FIG. 2 is a block diagram of a configuration of a wireless probe according to an embodiment;
 FIG. 3 is a block diagram of a configuration of an ultrasound imaging apparatus according to an embodiment;
 FIG. 4 is a block diagram of a configuration of an ultrasound imaging apparatus according to another embodiment;
 FIG. 5 is a flowchart of a method of operating an ultrasound imaging apparatus according to an embodiment;
 FIG. 6A is a diagram for explaining detection of a region having low image quality among regions in an ultrasound image, according to an embodiment;
 FIG. 6B is a diagram for explaining detection of a region having low image quality among regions in an ultrasound image, according to another embodiment;
 FIG. 7A is a diagram for explaining a factor that degrades the quality of an ultrasound image, according to an embodiment;
 FIG. 7B is a diagram for explaining a method of improving the quality of an ultrasound image, according to an embodiment;
 FIG. 8 is a flowchart of a method of operating an ultrasound imaging apparatus, according to another embodiment;
 FIG. 9 is diagram for explaining a first ultrasound image and a map representing a quality of the first ultrasound image, according to an embodiment;
 FIG. 10 is a diagram for explaining a first ultrasound image obtained before undergoing improvement of image quality and a second ultrasound image obtained after undergoing improvement of image quality, according to an embodiment;
 FIG. 11 is a flowchart of a method of operating an ultrasound imaging apparatus, according to another embodiment;
 and
 FIG. 12 is a diagram for explaining a method of controlling an operation of an ultrasound imaging apparatus based on a user input, according to an embodiment.

BEST MODE

[0029] Provided is an ultrasound imaging apparatus including a probe configured to transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object; and a processor configured to generate a first ultrasound image representing the object, detect at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion, control the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region, and generate a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

MODE FOR INVENTION

[0030] The terms used in this specification are those general terms currently widely used in the art in consideration of functions regarding the inventive concept, but the terms may vary according to the intention of those of ordinary skill in the art, precedents, or new technology in the art. Also, some terms may be arbitrarily selected by the applicant, and in this case, the meaning of the selected terms will be described in detail in the detailed description of the present specification. Thus, the terms used herein have to be defined based on the meaning of the terms together with the description throughout the specification.

[0031] When a part "includes" or "comprises" an element, unless there is a particular description contrary thereto, the part can further include other elements, not excluding the other elements. Also, the term "unit" in the embodiments of the present invention means a software component or hardware component such as a field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC), and performs a specific function. However, the term "unit" is not limited to software or hardware. The "unit" may be formed so as to be in an addressable storage medium, or may be formed so as to operate one or more processors. Thus, for example, the term "unit" may refer to components such as software components, object-oriented software components, class components, and task components, and may include processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, micro

codes, circuits, data, a database, data structures, tables, arrays, or variables. A function provided by the components and "units" may be associated with the smaller number of components and "units", or may be divided into additional components and "units".

[0032] It will be understood that, although the terms "first", "second", etc. may be used herein to describe various elements and/or components, these elements and/or components should not be limited by these terms. These terms are only used to distinguish one element or component from another element or component. For example, a first element or component may be termed a second element or component or vice versa without departing from the teachings of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0033] Throughout the specification, an "image" may mean multi-dimensional data formed of discrete image elements, e.g., pixels in a two-dimensional (2D) image and voxels in a three-dimensional (3D) image.

[0034] Throughout the specification, an "ultrasound image" refers to an image of an object, which is obtained using ultrasound waves. An ultrasound image may be an image obtained by transmitting ultrasound signals generated by transducers of a probe to an object and receiving information about echo signals reflected from the object. Furthermore, an ultrasound image may take different forms. For example, the ultrasound image may be at least one of an amplitude (A) mode image, a brightness (B) mode image, a color (C) mode image, and a Doppler (D) mode image. In addition, according to an embodiment, an ultrasound image may be a 2D or three-dimensional (3D) image.

[0035] Furthermore, an "object" may be a human, an animal, or a part of a human or animal. For example, the object may be an organ (e.g., the liver, the heart, the womb, the brain, a breast, or the abdomen), a blood vessel, or a combination thereof. Also, the object may be a phantom. The phantom means a material having a density, an effective atomic number, and a volume that are approximately the same as those of an organism.

[0036] Throughout the specification, a "user" may be, but is not limited to, a medical expert, for example, a medical doctor, a nurse, a medical laboratory technologist, or a medical imaging expert, or a technician who repairs medical apparatuses.

[0037] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein.

[0038] FIG. 1 is a block diagram showing a configuration of an ultrasound diagnosis apparatus 100 according to an embodiment.

[0039] Referring to FIG. 1, the ultrasound diagnosis apparatus 100 according to the present embodiment may include a probe 20, an ultrasound transceiver 115, an image processor 150, a display 160, a communication module 170, a memory 180, an input device 190, and a controller 195, which may be connected to one another via a bus 185. The image processor 150 may include an image generator 155, a cross-section information detector 130, and the display 160.

[0040] It will be understood by those of ordinary skill in the art that the ultrasound diagnosis apparatus 100 may further include common components other than those shown in FIG. 1.

[0041] In some embodiments, the ultrasound diagnosis apparatus 100 may be a cart type apparatus or a portable type apparatus. Examples of portable ultrasound diagnosis apparatuses may include, but are not limited to, a picture archiving and communication system (PACS) viewer, a smartphone, a laptop computer, a personal digital assistant (PDA), and a tablet PC.

[0042] The probe 20 transmits ultrasound waves to an object 10 in response to a driving signal applied by the ultrasound transceiver 115 and receives echo signals reflected by the object 10. The probe 20 includes a plurality of transducers, and the plurality of transducers oscillate in response to electric signals and generate acoustic energy, that is, ultrasound waves. Furthermore, the probe 20 may be connected to the main body of the ultrasound diagnosis apparatus 100 by wire or wirelessly, and according to embodiments, the ultrasound diagnosis apparatus 100 may include a plurality of probes 20.

[0043] A transmitter 110 supplies a driving signal to the probe 20. The transmitter 110 includes a pulse generator 112, a transmission delaying unit 114, and a pulser 116. The pulse generator 112 generates pulses for forming transmission ultrasound waves based on a predetermined pulse repetition frequency (PRF), and the transmission delaying unit 114 delays the pulses by delay times necessary for determining transmission directionality. The pulses which have been delayed correspond to a plurality of piezoelectric vibrators included in the probe 20, respectively. The pulser 116 applies a driving signal (or a driving pulse) to the probe 20 based on timing corresponding to each of the pulses which have been delayed.

[0044] A receiver 120 generates ultrasound data by processing echo signals received from the probe 20. The receiver 120 may include an amplifier 122, an analog-to-digital converter (ADC) 124, a reception delaying unit 126, and a summing unit 128. The amplifier 122 amplifies echo signals in each channel, and the ADC 124 performs analog-to-digital conversion with respect to the amplified echo signals. The reception delaying unit 126 delays digital echo signals output by the ADC 124 by delay times necessary for determining reception directionality, and the summing unit 128 generates ultrasound

data by summing the echo signals processed by the reception delaying unit 126.

[0045] The image processor 150 generates an ultrasound image by scan-converting ultrasound data generated by the ultrasound transceiver 115.

[0046] The ultrasound image may be not only a grayscale ultrasound image obtained by scanning an object in an amplitude (A) mode, a brightness (B) mode, and a motion (M) mode, but also a Doppler image showing a movement of an object. The Doppler image may be a blood flow Doppler image showing flow of blood (also referred to as a color Doppler image), a tissue Doppler image showing a movement of tissue, or a spectral Doppler image showing a moving speed of an object as a waveform.

[0047] A B mode processor 141 extracts B mode components from ultrasound data and processes the B mode components. An image generator 155 may generate an ultrasound image indicating signal intensities as brightness based on the extracted B mode components 141.

[0048] Similarly, a Doppler processor 142 may extract Doppler components from ultrasound data, and the image generator 155 may generate a Doppler image indicating a movement of an object as colors or waveforms based on the extracted Doppler components.

[0049] According to an embodiment, the image generator 155 may generate a 2D or 3D ultrasound image of an object 10 and may also generate an elasticity image by imaging deformation of the object 10 due to pressure. Furthermore, the image generator 155 may display various pieces of additional information in an ultrasound image by using text and graphics. In addition, the generated ultrasound image may be stored in the memory 180.

[0050] A display 160 displays the generated ultrasound image. The display 160 may display not only an ultrasound image, but also various pieces of information processed by the ultrasound diagnosis apparatus 100 on a screen image via a graphical user interface (GUI). In addition, the ultrasound diagnosis apparatus 100 may include two or more displays 160 according to embodiments.

[0051] The display 160 may include at least one of a liquid crystal display (LCD), a thin film transistor-LCD (TFT-LCD), an organic light-emitting diode (OLED) display, a flexible display, a 3D display, and an electrophoretic display.

[0052] Furthermore, when the display 160 and a user input device form a layer structure to form a touch screen, the display 160 may be used not only as an output device but also as an input device via which a user inputs information via a touch.

[0053] The touch screen may be configured to detect a position of a touch input, a touched area, and pressure of a touch. The touch screen may also be configured to detect both a real-touch and a proximity-touch.

[0054] In the present specification, a 'real-touch' means that a pointer actually touches a screen, and a 'proximity-touch' means that a pointer does not actually touch a screen but approaches the screen while being separated from the screen by a predetermined distance. A 'pointer' used herein means a tool for touching a particular portion on or near a displayed screen. Examples of the pointer may include a stylus pen and a body part such as a finger.

[0055] Although not shown, the ultrasound diagnosis apparatus 100 may include various sensors that are disposed within or near the touch screen so as to sense a real-touch or proximity-touch on the touch screen. A tactile sensor is an example of the sensors for sensing a touch on the touch screen.

[0056] The tactile sensor is used to sense a touch of a particular object to the same or greater degree than the degree to which a human can sense the touch. The tactile sensor may detect various pieces of information including the roughness of a contact surface, the hardness of an object to be touched, the temperature of a point to be touched, etc.

[0057] A proximity sensor is another example of the sensors for sensing a touch. The proximity sensor refers to a sensor that detects the presence of an object that is approaching or is located near a predetermined detection surface by using the force of an electromagnetic field or infrared light without mechanical contact.

[0058] Examples of the proximity sensor include a transmissive photoelectric sensor, a direct reflective photoelectric sensor, a mirror reflective photoelectric sensor, a high-frequency oscillation proximity sensor, a capacitive proximity sensor, a magnetic proximity sensor, an infrared proximity sensor, and the like.

[0059] The communication module 170 is connected to a network 30 by wire or wirelessly to communicate with an external device or a server. The communication module 170 may exchange data with a hospital server or another medical apparatus in a hospital, which is connected thereto via a PACS. Furthermore, the communication module 170 may perform data communication according to the digital imaging and communications in medicine (DICOM) standard.

[0060] The communication module 170 may transmit or receive data related to diagnosis of an object, e.g., an ultrasound image, ultrasound data, and Doppler data of the object, via the network 30 and may also transmit or receive medical images captured by another medical apparatus, e.g., a computed tomography (CT) apparatus, a magnetic resonance imaging (MRI) apparatus, or an X-ray apparatus. Furthermore, the communication module 170 may receive information about a diagnosis history or medical treatment schedule of a patient from a server and utilizes the received information to diagnose the patient. Furthermore, the communication module 170 may perform data communication not only with a server or a medical apparatus in a hospital, but also with a portable terminal of a medical doctor or patient.

[0061] The communication module 170 is connected to the network 30 by wire or wirelessly to exchange data with a server 32, a medical apparatus 34, or a portable terminal 36. The communication module 170 may include one or more

components for communication with external devices. For example, the communication module 1300 may include a local area communication module 171, a wired communication module 172, and a mobile communication module 173.

[0062] The local area communication module 171 refers to a module for local area communication within a predetermined distance. Examples of local area communication techniques according to an embodiment may include, but are not limited to, wireless LAN, Wi-Fi, Bluetooth, ZigBee, Wi-Fi Direct (WFD), ultra wideband (UWB), infrared data association (IrDA), Bluetooth low energy (BLE), and near field communication (NFC).

[0063] The wired communication module 172 refers to a module for communication using electric signals or optical signals. Examples of wired communication techniques according to an embodiment may include communication via a twisted pair cable, a coaxial cable, an optical fiber cable, and an Ethernet cable.

[0064] The mobile communication module 173 transmits or receives wireless signals to or from at least one selected from a base station, an external terminal, and a server on a mobile communication network. The wireless signals may be voice call signals, video call signals, or various types of data for transmission and reception of text/multimedia messages.

[0065] The memory 180 stores various data processed by the ultrasound diagnosis apparatus 100. For example, the memory 180 may store medical data related to diagnosis of an object, such as ultrasound data and an ultrasound image that are input or output, and may also store algorithms or programs which are to be executed in the ultrasound diagnosis apparatus 100.

[0066] The memory 180 may be any of various storage media, e.g., a flash memory, a hard disk drive, EEPROM, etc. Furthermore, the ultrasound diagnosis apparatus 100 may utilize web storage or a cloud server that performs the storage function of the memory 180 online.

[0067] The input device 190 generates input data for controlling an operation of the ultrasound diagnosis apparatus 100. The input device 190 may include hardware components, such as a keypad, a mouse, a touch pad, a track ball, and a jog switch, but is not limited thereto. The input device 190 may further include any of various other components including an electrocardiogram (ECG) measuring module, a respiration measuring module, a voice recognition sensor, a gesture recognition sensor, a fingerprint recognition sensor, an iris recognition sensor, a depth sensor, a distance sensor, etc.

[0068] In particular, the input device 190 may also include a touch screen in which a touch pad forms a layer structure with the display 160.

[0069] In this case, according to an embodiment, the ultrasound diagnosis apparatus 100 may display an ultrasound image in a predetermined mode and a control panel for the ultrasound image on a touch screen. The ultrasound diagnosis apparatus 100 may also detect a user's touch gesture performed on an ultrasound image via the touch screen.

[0070] According to an embodiment, the ultrasound diagnosis apparatus 100 may include some buttons that are frequently used by a user among buttons that are included in a control panel of a general ultrasound apparatus, and provide the remaining buttons in the form of a GUI via a touch screen.

[0071] The controller 195 may control all operations of the ultrasound diagnosis apparatus 100. In other words, the controller 195 may control operations among the probe 20, the ultrasound transceiver 100, the image processor 150, the communication module 170, the memory 180, and the input device 190 shown in FIG. 1.

[0072] All or some of the probe 20, the ultrasound transceiver 115, the image processor 150, the communication module 170, the memory 180, the input device 190, and the controller 195 may be implemented as software modules. However, embodiments of the present invention are not limited thereto, and some of the components stated above may be implemented as hardware modules. Furthermore, at least one selected from the ultrasound transceiver 115, the image processor 150, and the communication module 170 may be included in the controller 195. However, embodiments of the present invention are not limited thereto.

[0073] FIG. 2 is a block diagram showing a configuration of a wireless probe 2000 according to an embodiment. As described above with reference to FIG. 1, the wireless probe 2000 may include a plurality of transducers, and, according to embodiments, may include some or all of the components of the ultrasound transceiver 100 shown in FIG. 1.

[0074] The wireless probe 2000 according to the embodiment shown in FIG. 2 includes a transmitter 2100, a transducer 2200, and a receiver 2300. Since descriptions thereof are given above with reference to FIG. 1, detailed descriptions thereof will be omitted here. In addition, according to embodiments, the wireless probe 2000 may selectively include a reception delaying unit 2330 and a summing unit 2340.

[0075] The wireless probe 2000 may transmit ultrasound signals to the object 10, receive echo signals from the object 10, generate ultrasound data, and wirelessly transmit the ultrasound data to the ultrasound diagnosis apparatus 1000 shown in FIG. 1.

[0076] The wireless probe 2000 may be a smart device including a transducer array that is capable of performing an ultrasound scan. In detail, the wireless probe 2000 is a smart device that acquires ultrasound data by scanning an object via the transducer array. Then, the wireless probe 2000 may generate an ultrasound image by using the acquired ultrasound data and/or display the ultrasound image. The wireless probe 2000 may include a display via which a screen including at least one ultrasound image and/or a user interface screen for controlling an operation of scanning an object

may be displayed.

[0077] While the user is scanning a predetermined body part of a patient that is an object by using the wireless probe 2000, the wireless probe 2000 and the ultrasound diagnosis apparatus 100 may continue to transmit or receive certain data therebetween via a wireless network. In detail, while the user is scanning a predetermined body part of a patient that is an object by using the wireless probe 2000, the wireless probe 2000 may transmit ultrasound data to the ultrasound diagnosis apparatus 100 in real-time via the wireless network. The ultrasound data may be updated in real-time as an ultrasound scan continues and then be transmitted from the wireless probe 2000 to the ultrasound diagnosis apparatus 100.

[0078] FIG. 3 is a block diagram of a configuration of an ultrasound imaging apparatus 300 according to an embodiment.

[0079] Referring to FIG. 3, the ultrasound imaging apparatus 300 according to the present embodiment may include a probe 310 and a processor 320. However, all of the components shown in FIG.3 are not essential components. The ultrasound imaging apparatus 300 may include more or fewer components than those shown in FIG. 3.

[0080] The probe 310 may include a plurality of transducers that convert an ultrasound signal into an electrical signal or vice versa. In other words, the probe 310 may include a transducer array consisting of a plurality of transducers. The plurality of transducers may be arranged in a one-dimensional (1D) or 2D array, and each of the plurality of transducers generates ultrasound signals separately or simultaneously. An ultrasound signal transmitted by each transducer is reflected off a discontinuous impedance surface within the object. Each transducer may convert a received reflected echo signal into an electrical reception signal.

[0081] The probe 310 may transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object. In this case, the first path may be determined based on information about a position of an origin of an ultrasound beam composed of ultrasound signals and information about a transmission direction of the ultrasound beam. Furthermore, the information about a transmission direction of the ultrasound beam may be information about an angle between the transmission direction of the ultrasound beam and a transducer array.

[0082] The processor 320 may acquire first ultrasound data with respect to an object from reflected echo signals and generate a first ultrasound image based on the first ultrasound data. The processor 320 may detect at least one region having low image quality among regions in the first ultrasound image according to a predetermined criterion.

[0083] For example, when a region having low image quality is detected in the first ultrasound image according to the predetermined criterion, dual apodization with cross-correlation (DAX) may be used. In detail, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point may be detected as a region having low image quality. A point where information about an ultrasound image is to be acquired is referred to as a focal point.

[0084] More specifically, the ultrasound imaging apparatus 300 may generate lines RX1 and RX2 by applying different apodization functions to an echo signal. The ultrasound imaging apparatus 300 may calculate a DAX correlation by performing an arithmetic operation on the lines RX1 and RX2 according to Math Figure 1 below:

Math Figure 1

$$p(i,j) = \frac{\sum_{k=i-A}^{i+A} RX1(k,j)RX2(k,j)}{\sqrt{\sum_{k=i-A}^{i+A} RX1(k,j)^2} \sqrt{\sum_{k=i-A}^{i+A} RX2(k,j)^2}}$$

where i and j represent a sample and a beam, respectively.

[0085] Furthermore, when a region having low image quality is detected in the first ultrasound image according to the predetermined criterion, a ratio representing consistency may be used. The ratio may be calculated by using Math Figure 2 below:

Math Figure 2

$$|\sum S_n(t)|^2 / \sum |S_n(t)|^2$$

where $s_n(t)$ denotes delayed ultrasound data for channel n.

[0086] The above-described predetermined criterion is merely an example, and it will be apparent to those of ordinary

skill in the art that a region having low image quality may be detected in the first ultrasound image according to other criteria.

[0087] The probe 310 may transmit an ultrasound beam composed of ultrasound signals to an object in a plurality of directions and receive echo signals respectively reflected from the object based on the plurality of directions. By using the echo signals reflected from the object, the processor 320 may detect at least one region having low image quality among regions in the first ultrasound image according to a predetermined criterion.

[0088] The processor 320 may control an ultrasound signal to be transmitted along a second path based on the at least one region detected as a region having low image quality. The second path is different from the first path. Furthermore, transmission of an ultrasound signal along the first path may be achieved by focusing the ultrasound signal at a first focal point. Transmission of an ultrasound signal along the second path may be achieved by focusing the ultrasound signal at a second focal point.

[0089] The processor 320 may generate a second ultrasound image of an object based on an echo signal generated in response to an ultrasound signal transmitted to the object along the second path.

[0090] The processor 320 may control an ultrasound signal to be transmitted along a third path based on at least one region detected as a region having low image quality. The processor 320 may generate the second ultrasound image of the object based on the echo signals respectively generated in response to the ultrasound signals transmitted to the object along the second and third paths.

[0091] The processor 320 may control the probe 310 to perform beamforming by using a predetermined number of sub-apertures into which the plurality of transducers in the probe 310 are split. The beamforming is a process of increasing the intensity of ultrasound signals by overlapping the ultrasound signals during transmission and reception thereof via the plurality of transducers.

[0092] The ultrasound imaging apparatus 300 may obtain an ultrasound image by using another spatial path in order to improve an image quality of a region having low image quality in the ultrasound image.

[0093] The ultrasound imaging apparatus 300 may include a central arithmetic processor that controls overall operations of the probe 310 and the processor 320. The central arithmetic processor may be implemented as an array of a plurality of logic gates or a combination of a general purpose microprocessor and a program that can be run on the general purpose microprocessor. Furthermore, it will be appreciated by those of ordinary skill in the art to which the present embodiment pertains that the central arithmetic processor may be formed by different types of hardware.

[0094] FIG. 4 is a block diagram of a configuration of an ultrasound imaging apparatus 400 according to another embodiment.

[0095] Referring to FIG. 4, the ultrasound imaging apparatus 400 according to the present embodiment may include a probe 410, a processor 420, a display 430, and a user interface 440.

[0096] Since the probe 410 and the processor 420 of the ultrasound imaging apparatus 400 of FIG. 4 respectively correspond to the probe 310 and the processor 320 of the ultrasound imaging apparatus 300 of FIG. 3, descriptions that are already provided with respect to FIG. 3 will be omitted below. The ultrasound imaging apparatus 400 may include more or fewer components than those shown in FIG. 4.

[0097] The display 430 may display a predetermined screen. In detail, the display 430 may display a predetermined screen according to control by the processor 420. The display 430 includes a display panel (not shown) and displays a screen of the user interface 440, a medical image screen, etc. on the display panel.

[0098] The display 430 may display at least one of first and second ultrasound images. In this case, the first ultrasound image is generated based on an echo signal generated in response to an ultrasound signal transmitted to an object along a first path. The second ultrasound image is generated based on an echo signal generated in response to an ultrasound signal transmitted to the object along a second path. The second path is set to improve image quality of a region having low image quality in the first ultrasound image.

[0099] The processor 420 may detect at least one region having low image quality among regions in the first ultrasound image according to a predetermined criterion. The display 430 may display a map representing the quality of the first ultrasound image based on the detected at least one region.

[0100] The display 430 may display a map by distinguishing the at least one region from the other regions. For example, the display 430 may display a region having low image quality by using a red color and a region having appropriately high image quality by using a green color. Furthermore, the display 430 may display a boundary of a region having low image quality as a dashed or thick solid line in such a manner as to distinguish the region having the low image quality from a region having the appropriately high image quality.

[0101] The user interface 440 refers to a device via which a user inputs data for controlling the ultrasound imaging apparatus 400. The user interface 440 may include hardware components, such as a keypad, a mouse, a touch pad, a track ball, and a jog switch, but is not limited thereto. Furthermore, the user interface 440 may further include any of various other input tools including a voice recognition sensor, a gesture recognition sensor, an iris recognition sensor, a depth sensor, a distance sensor, etc.

[0102] The user interface 440 may receive a user input for transmitting an ultrasound signal along the second path based on a region having low image quality. The processor 420 may control an ultrasound signal to be transmitted along

the second path based on the user input.

[0103] The user interface 440 may generate and output a user interface screen for receiving a predetermined command or data from the user. For example, the user interface 440 may generate and output a screen for setting at least one of an input for setting a position of an origin of an ultrasound beam in a map representing the quality of the first ultrasound image and an input for setting information about a transmission direction of the ultrasound beam.

[0104] The ultrasound imaging apparatus 400 may further include a storage device (not shown) and a communication module (not shown). The storage device and the communication module may respectively correspond to the memory 180 and the communication module 170 described with reference to FIG. 1. The storage device may store data related to an ultrasound image (e.g., an ultrasound image, ultrasound data, scan-related data, data related to diagnosis of a patient, etc.), data transmitted from an external device to the ultrasound imaging apparatus 400, etc. The data transmitted from the external device may include patient-related information, data necessary for diagnosis and treatment of a patient, a patient's past medical history, a medical work list corresponding to instructions regarding diagnosis of a patient, and the like.

[0105] The communication module may receive and/or transmit data from and/or to an external device. For example, the communication module may connect to a wireless probe or an external device via a communication network based on Wi-Fi or Wi-Fi Direct (WFD) technology. In detail, examples of a wireless communication network to which the communication module can connect may include, but are not limited to, Wireless LAN (WLAN), Wi-Fi, Bluetooth, ZigBee, WFD, Ultra Wideband (UWB), Infrared Data Association (IrDA), Bluetooth Low Energy (BLE), and Near Field Communication (NFC).

[0106] The ultrasound imaging apparatus 400 may include a central arithmetic processor that controls overall operations of the probe 410, the processor 420, the display 430, the user interface 440, the storage device, and the communication module. The central arithmetic processor may be implemented as an array of a plurality of logic gates or a combination of a general purpose microprocessor and a program that can be run on the general purpose microprocessor. Furthermore, it will be appreciated by those of ordinary skill in the art to which the present embodiment pertains that the central arithmetic processor may be formed by different types of hardware.

[0107] Hereinafter, various operations performed by the ultrasound imaging apparatus 300 (400) and applications thereof will be described in detail. Although none of the probe 310 (410), the processor 320 (420), the display 430, the user interface 440, the storage device, and the communication module are specified, features and aspects that would be clearly understood by and are obvious to those of ordinary skill in the art may be considered as a typical implementation.

The scope of the present inventive concept is not limited by a name of a particular component or physical/logical structure.

[0108] FIG. 5 is a flowchart of a method of operating an ultrasound imaging apparatus according to an embodiment.

[0109] Referring to FIG. 5, the ultrasound imaging apparatus may transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object (S510). In this case, the first path may be determined based on information about a position of an origin of an ultrasound beam composed of ultrasound signals and information about a transmission direction of the ultrasound beam. Furthermore, the information about a transmission direction of the ultrasound beam may be information about an angle between the transmission direction of the ultrasound beam and a transducer array.

[0110] The ultrasound imaging apparatus may generate a first ultrasound image of the object based on the reflected echo signal and detect at least one region having low image quality among regions in the first ultrasound image according to a predetermined criterion (S520).

[0111] In this case, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point may be detected as a region having low image quality.

[0112] Furthermore, the ultrasound imaging apparatus may transmit an ultrasound beam to the object in a plurality of directions and receive echo signals respectively reflected from the object based on the plurality of directions. By using the echo signals, the ultrasound imaging apparatus may detect at least one region having low image quality among regions in the first ultrasound image according to a predetermined criterion.

[0113] The ultrasound imaging apparatus may control an ultrasound signal to be transmitted along a second path based on the detected at least one region (S530). Furthermore, to improve an image quality of a region having low image quality, the ultrasound imaging apparatus may control an ultrasound signal to be transmitted along a third path, which is different from the second path, based on the detected at least one region.

[0114] The ultrasound imaging apparatus may generate a second ultrasound image of the object based on an echo signal generated in response to the ultrasound signal transmitted to the object along the second path (S540).

[0115] The ultrasound imaging apparatus may generate a second ultrasound image of the object based on the echo signals respectively generated in response to the ultrasound signals transmitted to the object along the second and third paths.

[0116] FIG. 6A is a diagram for explaining detection of a region having low image quality among regions in an ultrasound image, according to an embodiment.

[0117] An ultrasound imaging apparatus may generate a first ultrasound image based on an echo signal generated in response to an ultrasound signal transmitted to an object along a first path. In the presence of factors that degrade quality of the first ultrasound image, the quality of the first ultrasound image needs to be improved. The factors that degrade the quality of the first ultrasound image may be bone, fibrous tissue, adipose tissue, etc., but are not limited thereto. Since the factors are present in the object and cannot be removed directly, it is necessary to generate an ultrasound image without being affected much by the factors. The ultrasound imaging apparatus may detect a region having low image quality among regions in the first ultrasound image and generate a map representing a quality of the first ultrasound image based on the detected region.

[0118] FIG. 6A is a diagram for explaining a process of generating a map indicating the quality of an ultrasound image by detecting a region having low image quality among regions in the ultrasound image.

[0119] Referring to 610 of FIG. 6A, a transducer 611 of the ultrasound imaging apparatus may transmit an ultrasound signal to the object along a first path 613 and receive an echo signal that is focused at a first focal point F1 in an imaging area 612 by using an aperture from L1 to R1. Furthermore, the ultrasound imaging apparatus may receive an echo signal that is focused at a second focal point F2 in the imaging area 612 by using an aperture from L2 to R2.

[0120] In detail, for example, the ultrasound imaging apparatus may detect a region having low image quality in the first ultrasound image by using a DAX correlation. The ultrasound imaging apparatus may calculate a DAX correlation value for the first focal point F1 and a DAX correlation value for the second focal point F2 respectively by using different apodization functions. If the DAX correlation value for the first focal point F1 is close to or less than 1 by a predetermined value, the ultrasound imaging apparatus may determine a region 614 as having appropriately high image quality. Furthermore, if the DAX correlation value for the second focal point F2 is close to or less than 0, the ultrasound imaging apparatus may determine a region 615 as having low image quality.

[0121] FIG. 6B is a diagram for explaining detection of a region having low image quality among regions in an ultrasound image, according to another embodiment.

[0122] Referring to 620 of FIG. 6B, the transducer 611 of the ultrasound imaging apparatus may transmit an ultrasound signal to the object along a path 621 that is different from the first path 613 and receive an echo signal that is focused at a third focal point F3 in the imaging area 612 by using an aperture from L3 to R3. If a DAX correlation value for the third focal point F3 is close to or less than 1 by a predetermined value, the ultrasound imaging apparatus may determine a region 622 as being a region having appropriately high image quality. Furthermore, if a DAX correlation value for the third focal point F3 is close to or less than 0, the ultrasound imaging apparatus may determine a region 623 as being a region having low image quality.

[0123] The ultrasound imaging apparatus may transmit an ultrasound beam composed of ultrasound signals to the object in a plurality of directions and receive echo signals respectively reflected from the object based on the plurality of directions. The ultrasound imaging apparatus may detect a region having low image quality among regions in the first ultrasound image by using the reflected echo signals. By transmitting an ultrasound beam in a plurality of directions and receiving reflected echo signals, the ultrasound imaging apparatus may detect a region having low image quality in an ultrasound image more accurately and efficiently.

[0124] FIG. 7A is a diagram for explaining a factor that degrades the quality of an ultrasound image, according to an embodiment.

[0125] Referring to FIG. 7A, a transducer 711 may transmit an ultrasound signal to an object and receive an echo signal reflected from the object. When a factor 713 such as bone, fibrous tissue, or fat is in the object, an ultrasound signal cannot reach a far end inside the object. Thus, the ultrasound imaging apparatus is not able to receive an echo signal reflected from a region 714 within an imaging area 712. If the ultrasound imaging apparatus generates a first ultrasound image 710 of the object without receiving the echo signal reflected from the region 714, an image quality of the region 714 may be degraded. Thus, the ultrasound imaging apparatus may acquire a location of the factor 713 that degrades image quality by using a DAX correlation. The ultrasound imaging apparatus may transmit an ultrasound signal to the object based on the location of the factor 713.

[0126] FIG. 7B is a diagram for explaining a method of improving the quality of an ultrasound image according to an embodiment.

[0127] The ultrasound imaging apparatus may transmit an ultrasound beam to a region of interest (ROI) of an object in a plurality of directions and receive echo signals respectively reflected from the ROI of the object based on the plurality of directions. By using the echo signals reflected from the object, the ultrasound imaging apparatus may detect a region having low image quality among regions in a first ultrasound image according to a predetermined criterion.

[0128] When the ultrasound imaging apparatus transmits an ultrasound beam in directions that are perpendicular to the transducer 711, as shown in FIG. 7A, the ultrasound imaging apparatus is not able to receive echo signals reflected from the region 714 within the imaging area 712 due to the presence of the factor 713 (i.e., an obstacle) in the object. The ultrasound imaging apparatus may generate the first ultrasound image 710 based on echo signals reflected from the other regions excluding the region 714 and detect the region 714 having low image quality among regions in the first ultrasound image 710 according to a predetermined criterion.

[0129] As shown in FIG. 7B, the ultrasound imaging apparatus may determine second paths 721 and 722 so that ultrasound signals reach a region 714 without being obstructed by a factor 713 that degrades an image quality. In detail, the ultrasound imaging apparatus may determine a range of an aperture so as to transmit an ultrasound signal by focusing the ultrasound signal at a focal point within the region 714 having low image quality and to receive an echo signal without being disturbed by the factor 713 that degrades the image quality. The ultrasound imaging apparatus may transmit ultrasound signals to the region 714 along the second paths 721 and 722 and receive echo signals reflected from the region 714. The ultrasound imaging apparatus may generate a second ultrasound image 720 by using ultrasound data acquired from the echo signals.

[0130] FIG. 8 is a flowchart of a method of operating an ultrasound imaging apparatus according to another embodiment.

[0131] Referring to FIG. 8, the ultrasound imaging apparatus may display at least one of the first and second ultrasound images (S810). In this case, the first ultrasound image is generated based on the echo signal received in response to the ultrasound signal transmitted to the object along the first path. The second ultrasound image is generated based on the echo signal received in response to the ultrasound signal transmitted to the object along the second path. The second path is set to improve an image quality of the region having low image quality in the first ultrasound image.

[0132] The ultrasound imaging apparatus may display a map indicating a quality of the first ultrasound image based on the region detected as a region having low image quality (S820). According to an embodiment, after performing operation S540, the ultrasound imaging apparatus may perform operation S820 by skipping operation S810.

[0133] The ultrasound imaging apparatus may display a region having low image quality and a region having appropriately high image quality in the map in such a manner as to distinguish them from each other. For example, the regions having low image quality and having appropriately high image quality may be displayed using different colors. Furthermore, a boundary of the region having low image quality may be displayed as at least one of a solid line, a thick solid line, a dashed line, and a thick dashed line, and embodiments are not limited thereto.

[0134] Furthermore, the ultrasound imaging apparatus may display the first ultrasound image together with the map indicating the quality of the first ultrasound image. Furthermore, the ultrasound imaging apparatus may display at least one of the first ultrasound image, the second ultrasound image, and the map indicating the quality of the first ultrasound image.

[0135] FIG. 9 is diagram for explaining a first ultrasound image and a map indicating a quality of the first ultrasound image, according to an embodiment.

[0136] An ultrasound imaging apparatus generates an ultrasound image based on ultrasound data. A plurality of modes for providing an ultrasound image (hereinafter, referred to as a 'composite mode') may include a B-mode for providing a B-mode image, a Color Doppler mode (C-mode) or a Power Doppler mode (P-mode) for providing a color flow image, and a D- mode for providing a Doppler spectrum. The ultrasound imaging apparatus may display via a screen of a display an ultrasound image in one of the plurality of modes.

[0137] Referring to FIG. 9, the ultrasound imaging apparatus may transmit an ultrasound signal to a woman's uterus and acquire ultrasound data by receiving an echo signal reflected from the woman's uterus. The ultrasound imaging apparatus may generate a first ultrasound image 910 based on the acquired ultrasound data. The ultrasound imaging apparatus may also display the first ultrasound image 910 via a screen of the display. In this case, the first ultrasound image 910 may be a B-mode image showing the myometrium and endometrium of the uterus. In addition, due to calcification of the myometrium and endometrium, the quality of the first ultrasound image 910 may decrease away from a region where calcification occurs.

[0138] The ultrasound imaging apparatus may detect a region having low image quality among regions in the first ultrasound image 910 according to a predetermined criterion. The ultrasound imaging apparatus may display a map 920 indicating a quality of the first ultrasound image 910 in such a manner as to distinguish a region having low image quality from the other regions.

[0139] For example, in the map 920, the ultrasound imaging apparatus may display a region 921 having low image quality by using dark colors while displaying a region 923 having appropriately high image quality by using bright colors. Furthermore, the ultrasound imaging apparatus may display a boundary 922 of the region 921 having low image quality as one of a solid line, a thick solid line, a dashed line, and a thick dashed line. Furthermore, the ultrasound imaging apparatus may display the boundary 922 of the region 921 by using a red color. It will be understood by those of ordinary skill in the art that the ultrasound imaging apparatus may display the map 920 in such a manner as to distinguish the region 921 having low image quality from the region 923 having appropriately high image quality by using methods other than those described above.

[0140] FIG. 10 is a diagram for explaining a first ultrasound image obtained before undergoing improvement of image quality and a second ultrasound image obtained after undergoing improvement of image quality, according to an embodiment.

[0141] When a factor that obstructs a path of an ultrasound signal exists in an object, a quality of an ultrasound image may be degraded due to the presence of the factor. An image 1010 of FIG. 10 may be an ultrasound image obtained based on a reflected echo signal without taking into account a path of an ultrasound signal.

[0142] On the other hand, an image 1020 of FIG. 10 may be an ultrasound image obtained based on a reflected echo signal by taking into account a factor that obstructs a path of an ultrasound signal, i.e., by allowing the ultrasound signal to circumvent the factor and propagate into the entire area of the object.

[0143] By comparing the images 1010 and 1020 with each other, it can be seen that a region 1021 appears clearer than a region 1011 and that the number of black dots in a region 1022 is reduced compared to the number of black dots in a region 1012.

[0144] FIG. 11 is a flowchart of a method of operating an ultrasound imaging apparatus according to another embodiment.

[0145] Referring to FIG. 11, the ultrasound imaging apparatus may receive a user input for transmitting an ultrasound signal along a second path based on the detected at least one region (S1110). The ultrasound imaging apparatus may receive a user input for setting at least one piece of information from among information about a position of an origin of an ultrasound beam, information about a transmission direction of the ultrasound beam, and information about an aperture size. In this case, the user input may be received via a control panel, a track ball, a mouse, a keyboard, etc.

[0146] In detail, to determine the second path, the user may display the second path on a screen by using a keypad, a mouse, a touch screen, a track ball, a jog switch, etc.

[0147] The ultrasound imaging apparatus may control the ultrasound signal to be transmitted along the second path based on the user input (S1120).

[0148] FIG. 12 is a diagram for explaining a method of controlling an operation of an ultrasound imaging apparatus based on a user input, according to an embodiment.

[0149] Referring to FIG. 12, the ultrasound imaging apparatus may generate and output a user interface screen 1200 for setting transmission of an ultrasound signal along a second path based on a region having low image quality.

[0150] A user interface may also receive a predetermined command or data from the user via the user interface screen 1200. For example, the user interface may receive, from the user, at least one of a position of an origin of an ultrasound beam and a transmission direction of the ultrasound beam. The user interface screen 1200 may receive a manipulation signal via a user's touch input by using various input tools. The user interface screen 1200 may receive an input for adjusting via a user's hand or physical tool a position of an origin of an ultrasound beam, a transmission direction of the ultrasound beam, an aperture size, etc., displayed on the user interface screen 1200.

[0151] In detail, the user may input a drag and drop signal for determining second paths 1206 and 1207 via a touch pen 1205 so that an ultrasound signal may reach a region 1204 without being obstructed by a factor 1203 that degrades an image quality of an imaging area 1202. A transducer 1201 of the ultrasound imaging apparatus may transmit ultrasound signals to the region 1204 along the second paths 1206 and 1207 and receive echo signals reflected from the region 1204. The ultrasound imaging apparatus may generate a second ultrasound image based on ultrasound data acquired from the echo signals.

[0152] The ultrasound imaging apparatuses described above may be implemented using hardware components, software components, and/or a combination thereof. For example, the apparatuses and components illustrated in the embodiments may be implemented using one or more general-purpose or special-purpose computers, such as a processor, a controller, an arithmetic logic unit (ALU), a digital signal processor, a microcomputer, a field programmable array (FPA), a programmable logic unit (PLU), a microprocessor, or any other device capable of responding to and executing instructions.

[0153] A processing device may run an operating system (OS) and one or more software applications running on the OS. The processing device also may access, store, manipulate, process, and create data in response to execution of software.

[0154] Although a single processing device may be illustrated for convenience, one of ordinary skill in the art will appreciate that a processing device may include a plurality of processing elements and/or a plurality of types of processing elements. For example, a processing device may include a plurality of processors or a processor and a controller. In addition, the processing device may have different processing configurations such as parallel processors.

[0155] Software may include a computer program, a piece of code, an instruction, or one or more combinations thereof and independently or collectively instruct or configure the processing device to operate as desired.

[0156] Software and/or data may be embodied permanently or temporarily in any type of machine, component, physical equipment, virtual equipment, computer storage medium or device, or in a transmitted signal wave so as to be interpreted by the processing device or to provide instructions or data to the processing device. The software also may be distributed over network-coupled computer systems so that the software is stored and executed in a distributed fashion. In particular, the software and data may be stored in one or more computer-readable recording media.

[0157] The methods according to the embodiments may be recorded in non-transitory computer-readable recording media including program instructions to implement various operations embodied by a computer. The non-transitory computer-readable recording media may also include, alone or in combination with the program instructions, data files, data structures, and the like. The program instructions recorded in the non-transitory computer-readable recording media may be designed and configured specially for the exemplary embodiments or be known and available to those of ordinary

skill in computer software.

[0158] Examples of non-transitory computer-readable recording media include magnetic media such as hard disks, floppy disks, and magnetic tape, optical media such as CD-ROM discs and DVDs, magneto-optical media such as floptical discs, and hardware devices that are specially configured to store and perform program instructions, such as ROM, RAM, flash memory, and the like.

[0159] Examples of program instructions include both machine code, such as that produced by a compiler, and higher level code that may be executed by the computer using an interpreter.

[0160] The above-described hardware devices may be configured to act as one or more software modules in order to perform the operations of the above-described embodiments, or vice versa.

[0161] While one or more exemplary embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various modifications and changes in form and details may be made from the above descriptions without departing from the spirit and scope as defined by the following claims. For example, adequate effects may be achieved even if the above techniques are performed in a different order than that described above, and/or the aforementioned elements, such as systems, structures, devices, or circuits, are combined or coupled in different forms and modes than those described above or are replaced or supplemented by other components or their equivalents.

[0162] Thus, the scope of the present inventive concept is defined not by the detailed description thereof but by the appended claims and their equivalents.

Claims

1. An ultrasound imaging apparatus comprising:

a probe configured to transmit an ultrasound signal to an object along a first path and receive an echo signal reflected from the object; and
a processor configured to generate a first ultrasound image representing the object, detect at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion, control the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a focal point within a predetermined region of the object corresponding to the detected at least one region, and generate a second ultrasound image representing the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path.

2. The ultrasound imaging apparatus of claim 1, wherein the first path is determined based on information about a position of an origin of an ultrasound beam composed of the ultrasound signal and on information about a transmission direction of the ultrasound beam.

3. The ultrasound imaging apparatus of claim 1, wherein the probe is further configured to transmit an ultrasound beam composed of the ultrasound signal to the object in a plurality of directions and receive echo signals respectively reflected from the object based on the plurality of directions, and
wherein the processor is further configured to detect, according to a predetermined criterion, at least one region having low image quality among regions in the first ultrasound image by using the reflected echo signals.

4. The ultrasound imaging apparatus of claim 1, wherein when detecting the at least one region having low image quality according to the predetermined criterion, the processor detects, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point as a region having low image quality.

5. The ultrasound imaging apparatus of claim 1, further comprising a display configured to display at least one of the first and second ultrasound images, and display a map indicating quality of the first ultrasound image based on the detected at least one region.

6. The ultrasound imaging apparatus of claim 2, wherein the probe comprises a transducer array consisting of a plurality of transducers, wherein the information about the transmission direction of the ultrasound beam is information about an angle between the transmission direction of the ultrasound beam and the transducer array.

7. The ultrasound imaging apparatus of claim 1, wherein the ultrasound signal is transmitted along the first path while being focused at a first focal point, and the ultrasound signal is transmitted along the second path while being focused

at a second focal point.

- 5 **8.** The ultrasound imaging apparatus of claim 1, wherein the processor is further configured to control the ultrasound signal to be transmitted along a third path based on the at least one region and generate a second ultrasound image corresponding to the object based on an echo signal received in response to the ultrasound signal transmitted to the object along the second path and an echo signal received in response to the ultrasound signal transmitted to the object along the third path.
- 10 **9.** The ultrasound imaging apparatus of claim 1, further comprising a user interface configured to receive a user input for setting transmission of the ultrasound signal along the second path based on the at least one region, and wherein the processor is further configured to control the ultrasound signal to be transmitted along the second path based on the user input.
- 15 **10.** The ultrasound imaging apparatus of claim 1, wherein the processor is further configured to control the probe to perform beamforming by using a predetermined number of sub-apertures into which a plurality of transducers in the probe are divided.
- 20 **11.** A method of operating an ultrasound imaging apparatus, the method comprising:
 transmitting an ultrasound signal to an object along a first path and receiving an echo signal reflected from the object;
 generating a first ultrasound image representing the object and detecting at least one region having low image quality among regions in the generated first ultrasound image according to a predetermined criterion;
 controlling the ultrasound signal to be transmitted along a second path by focusing the ultrasound signal at a
 focal point within a predetermined region of the object corresponding to the detected at least one region; and
 generating a second ultrasound image representing the object based on an echo signal received in response
 to the ultrasound signal transmitted to the object along the second path.
- 30 **12.** The method of claim 11, wherein the first path is determined based on information about a position of an origin of an ultrasound beam composed of the ultrasound signal and on information about a transmission direction of the ultrasound beam.
- 35 **13.** The method of claim 11, wherein the transmitting of the ultrasound signal to the object along the first path and the receiving of the echo signal reflected from the object comprises transmitting an ultrasound beam composed of the ultrasound signal to the object in a plurality of directions and receiving echo signals respectively reflected from the object based on the plurality of directions, and
 wherein the generating of the first ultrasound image and the detecting of the at least one region having low image quality according to the predetermined criterion comprises detecting, according to a predetermined criterion, at least one region having low image quality among regions in the first ultrasound image by using the reflected echo signals.
- 40 **14.** The method of claim 11, wherein the detecting of the at least one region having low image quality according to the predetermined criterion comprises detecting, if a correlation value for a first focal point, which is acquired using different apodization functions, is less than a predetermined threshold value, a region in the first ultrasound image corresponding to the first focal point as a region having low image quality.
- 45 **15.** The method of claim 11, further comprising displaying at least one of the first and second ultrasound images.

FIG. 1

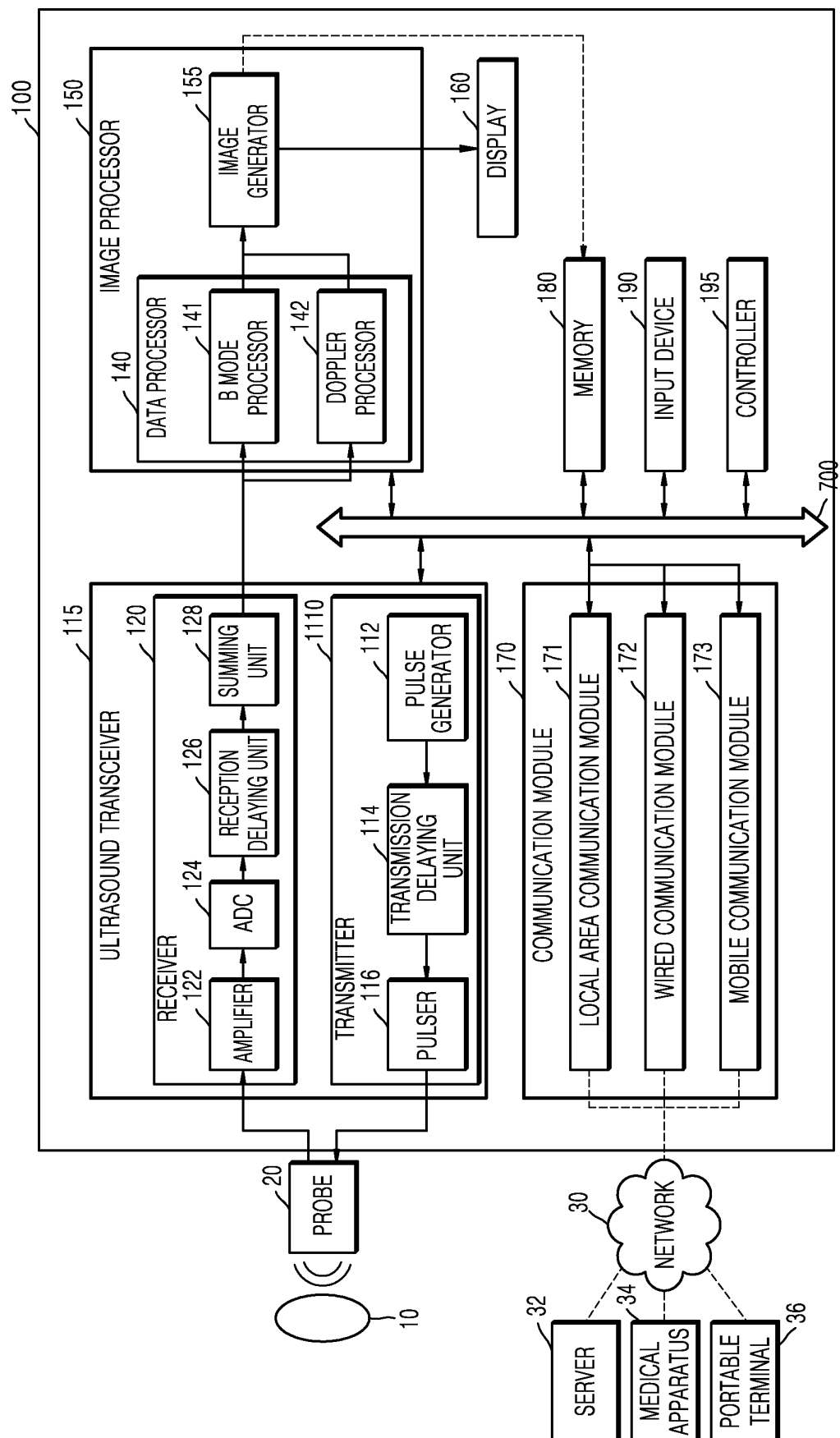


FIG. 2

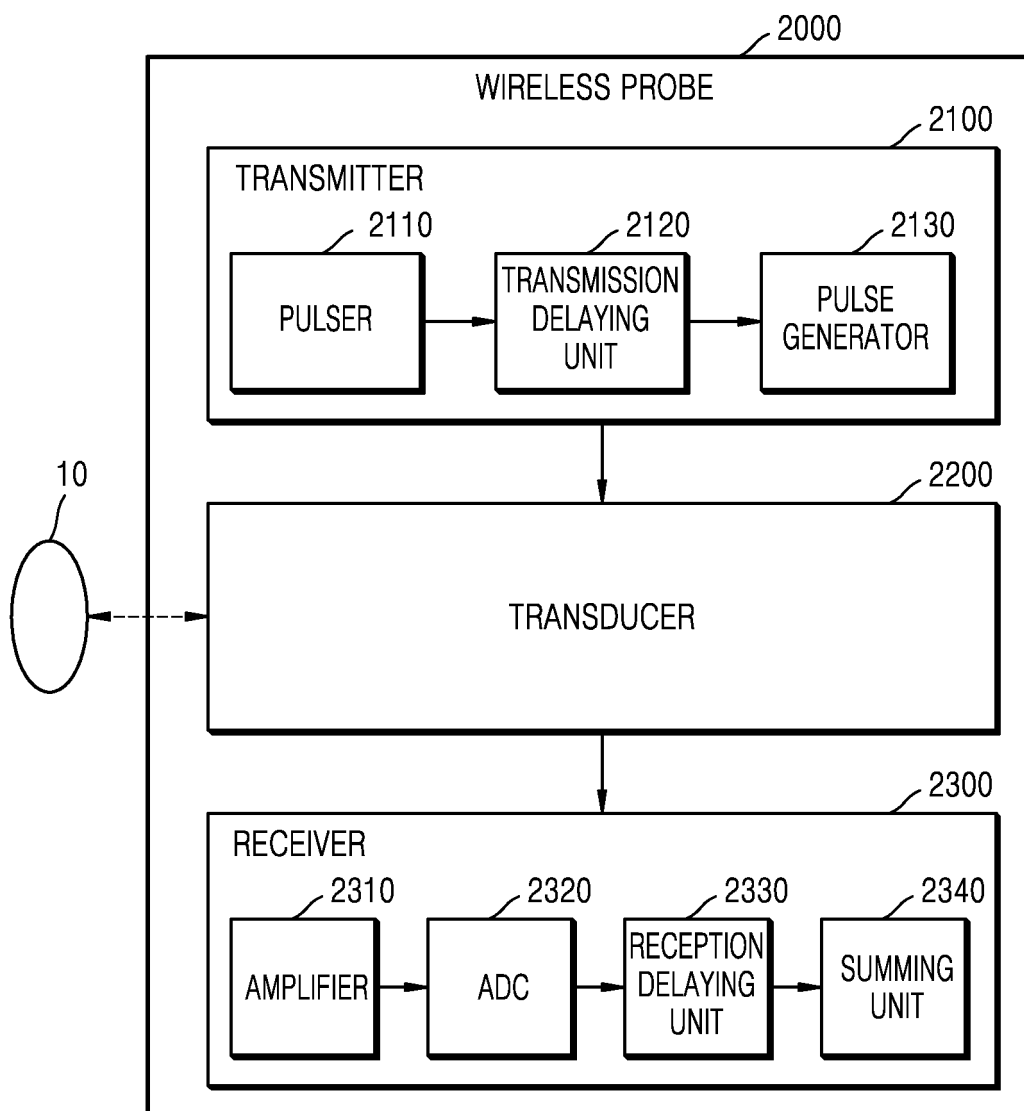


FIG. 3

300

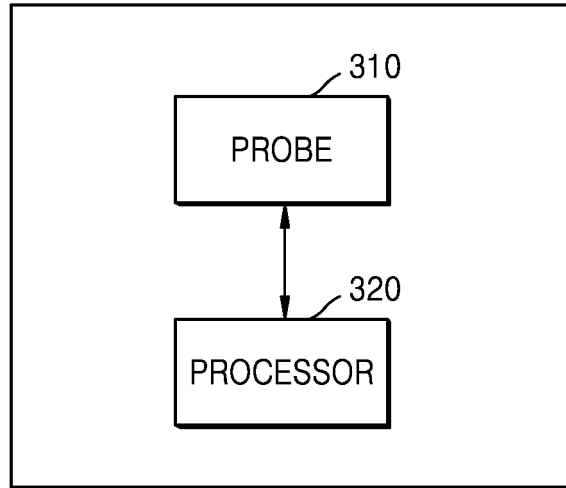


FIG. 4

400

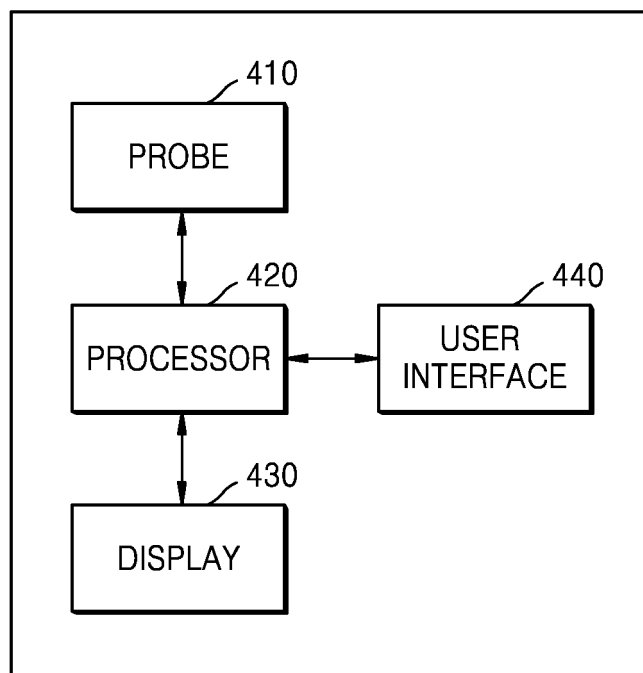


FIG. 5

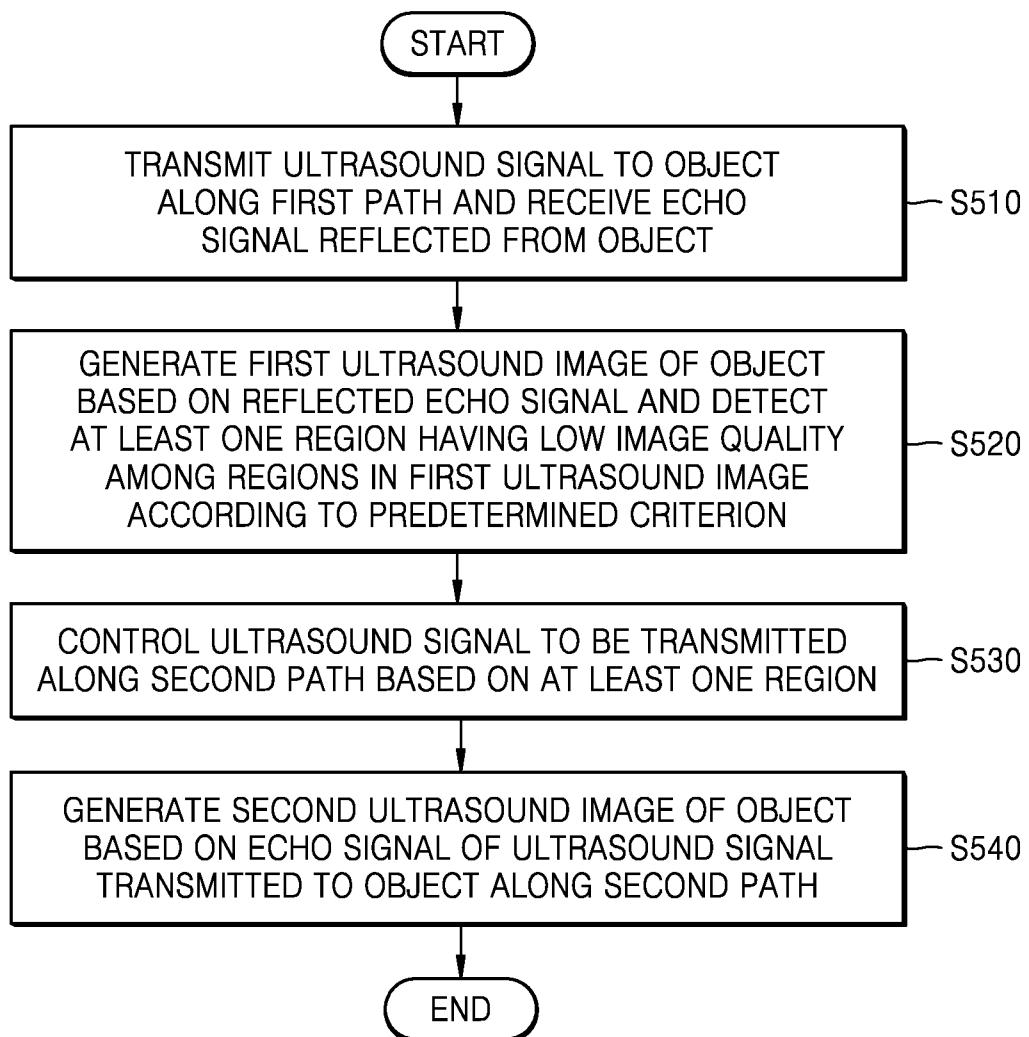


FIG. 6A

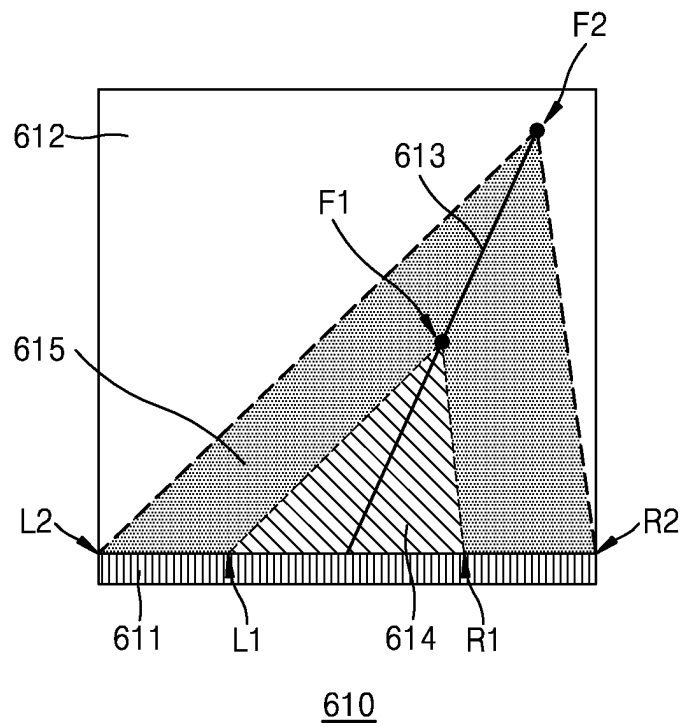


FIG. 6B

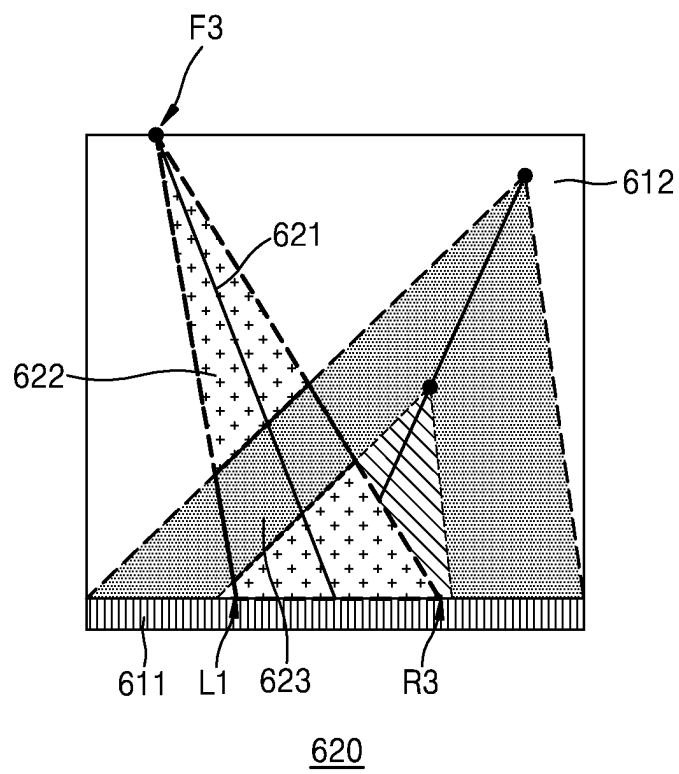


FIG. 7A

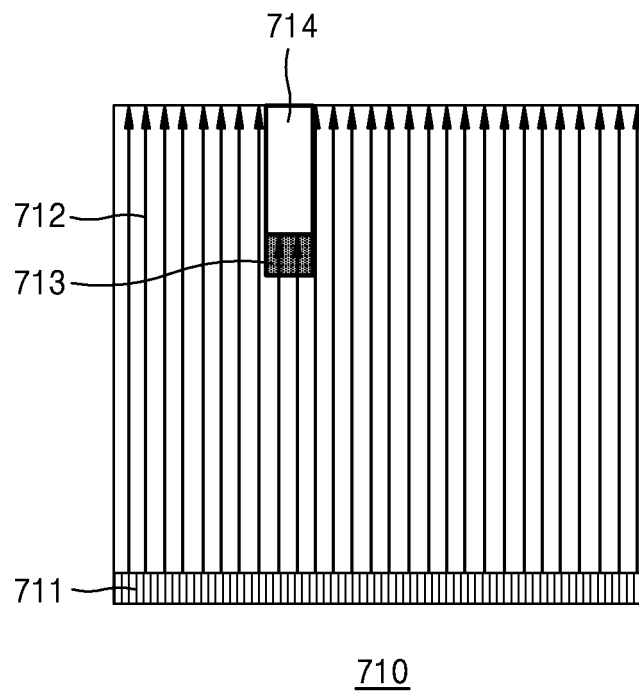


FIG. 7B

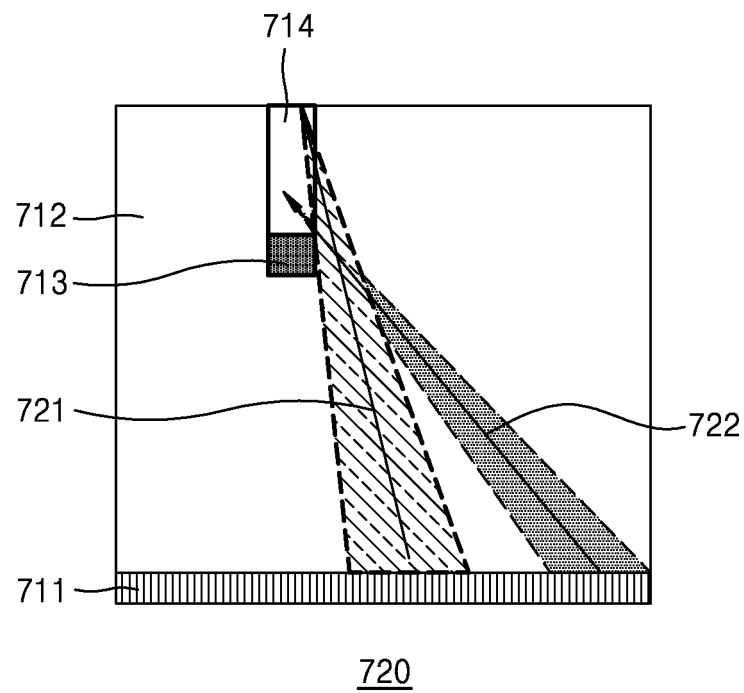


FIG. 8

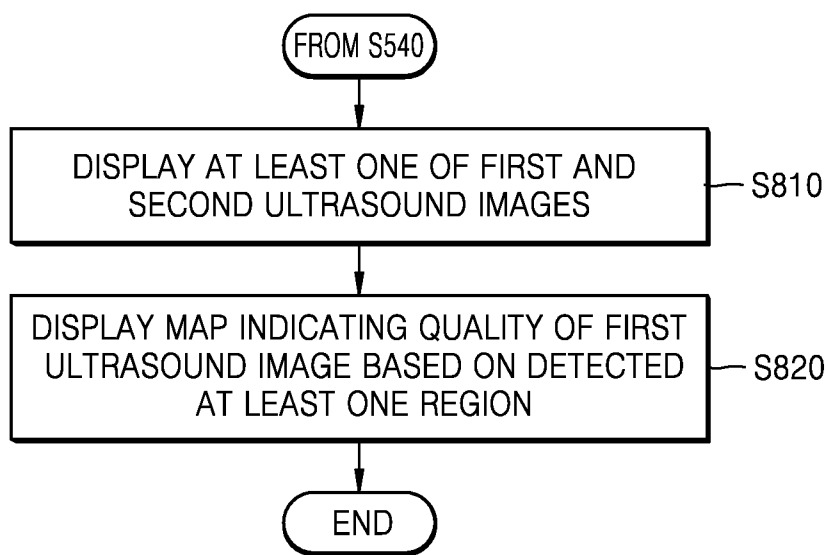


FIG. 9

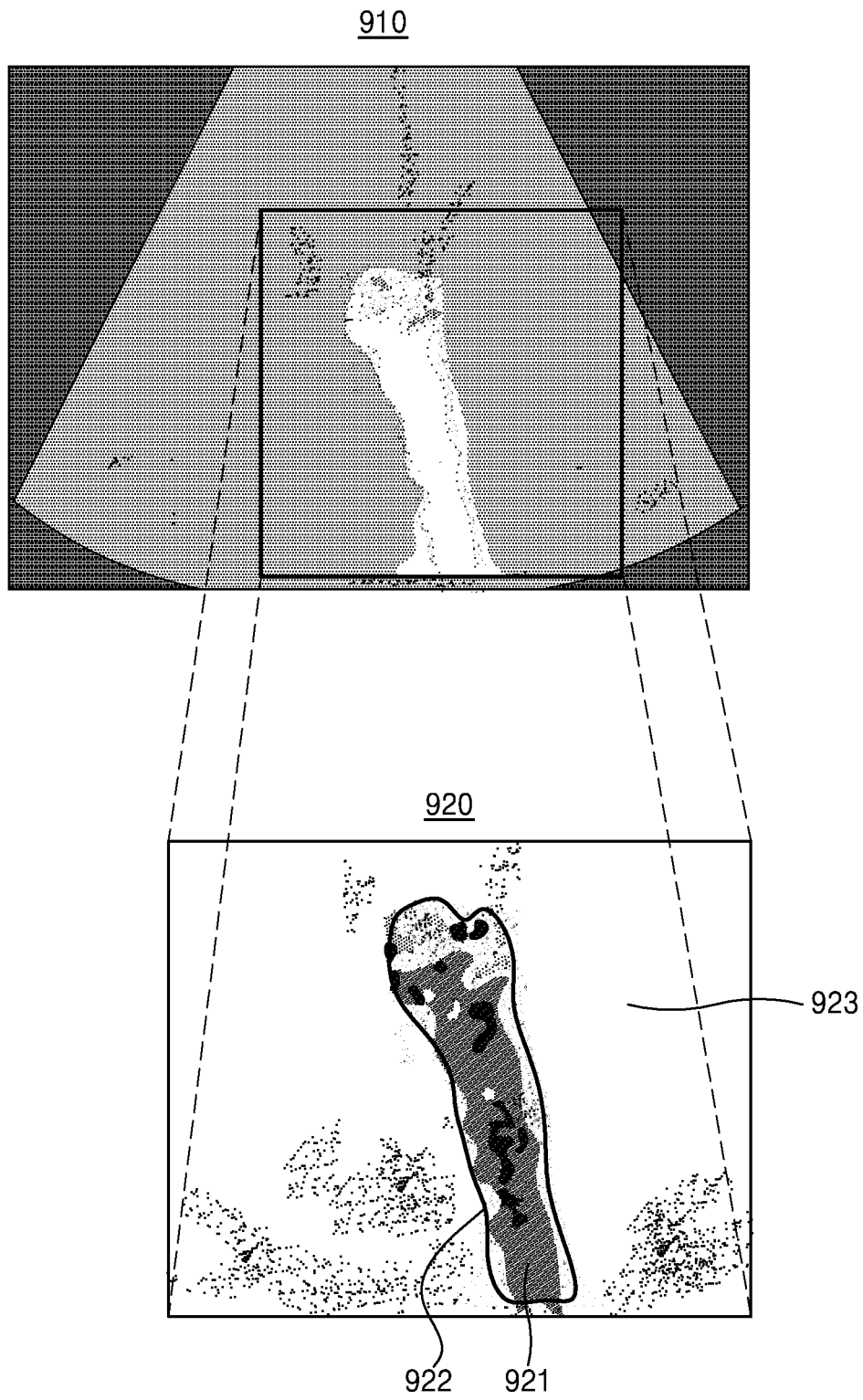


FIG. 10

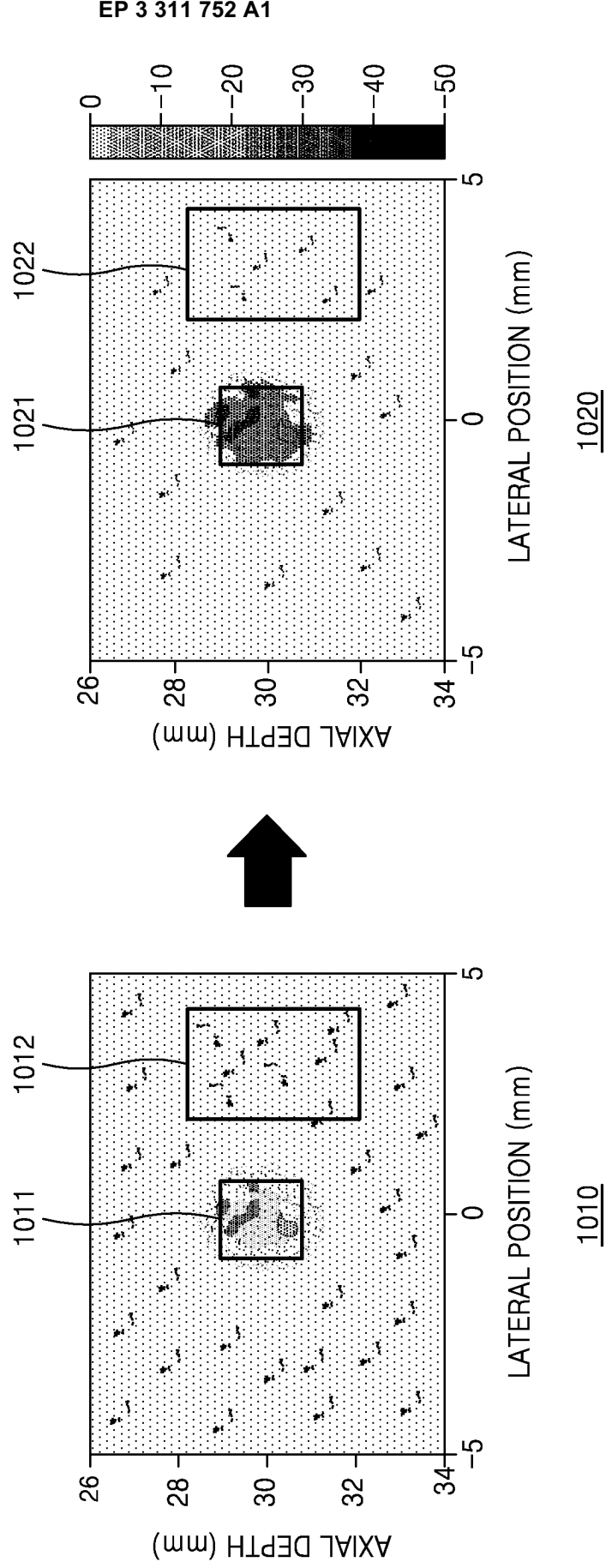


FIG. 11

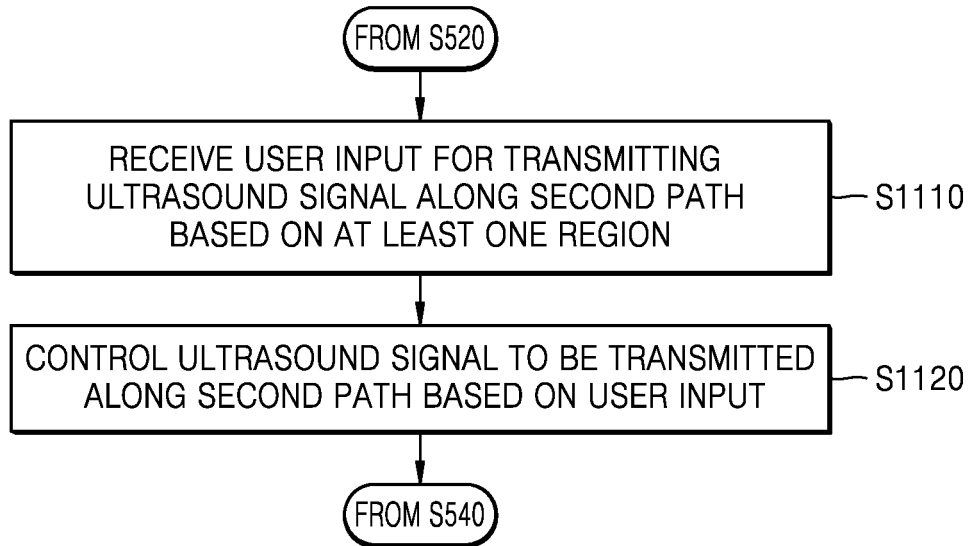
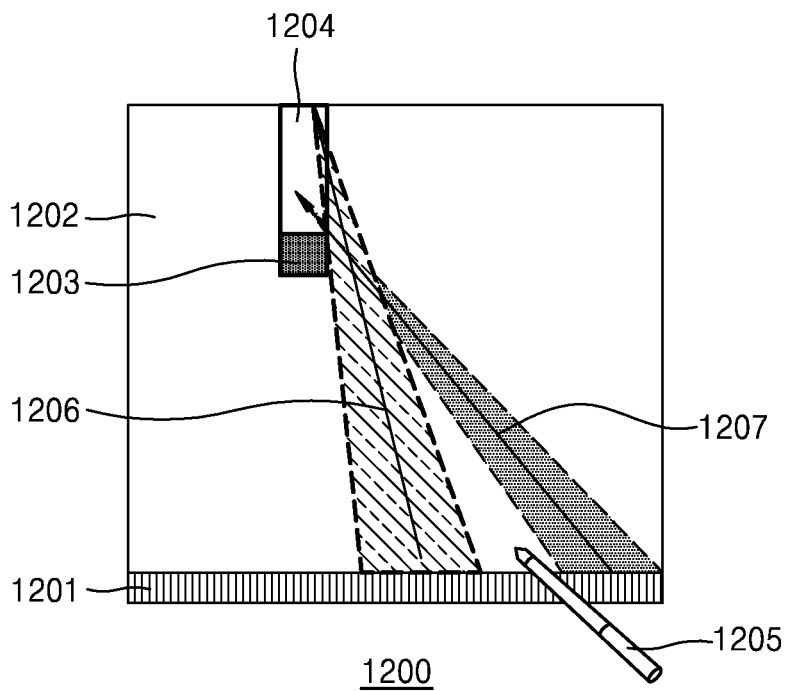


FIG. 12



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/006105

A. CLASSIFICATION OF SUBJECT MATTER

A61B 8/14(2006.01)i, A61B 8/08(2006.01)i, A61B 8/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B 8/14; A61B 8/08; A61B 8/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: ultrasound, quality, picture quality, region, detection, focusing, criterion

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-296336 A (GENERAL ELECTRIC CO.) 15 November 2007 See abstract, paragraphs [11]-[32], claim 1 and figures 1, 5.	1-15
Y	JP 2013-244164 A (FUJIFILM CORP.) 09 December 2013 See abstract, paragraph [11] and claims 8, 11.	1-15
A	JP 2007-117168 A (ALOKA CO., LTD.) 17 May 2007 See abstract, claims 1-8 and figures 1-3.	1-15
A	KR 10-2004-0070404 A (LG ELECTRONICS INC.) 09 August 2004 See abstract, claims 1-3 and figure 2.	1-15
A	JP 2014-068755 A (FUJIFILM CORP.) 21 April 2014 See abstract, claims 1-10 and figures 1-5.	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"G" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 SEPTEMBER 2016 (19.09.2016)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR



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Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2016/006105

Patent document cited in search report	Publication date	Patent family member	Publication date
JP 2007-296336 A	15/11/2007	CN 101066211 A CN 101066211 B DE 102007020862 A1 JP 5100193 B2 US 2007-0258631 A1 US 8081806 B2	07/11/2007 24/12/2014 22/11/2007 19/12/2012 08/11/2007 20/12/2011
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KR 10-2004-0070404 A	09/08/2004	NONE	
JP 2014-068755 A	21/04/2014	CN 104661598 A JP 2014-064856 A JP 5829198 B2 JP 5836241 B2 US 2015-0201909 A1 WO 2014-050889 A1	27/05/2015 17/04/2014 09/12/2015 24/12/2015 23/07/2015 03/04/2014

专利名称(译)	超声波装置及其操作方法		
公开(公告)号	EP3311752A4	公开(公告)日	2018-12-05
申请号	EP2016811860	申请日	2016-06-09
[标]申请(专利权)人(译)	三星麦迪森株式会社		
申请(专利权)人(译)	三星MEDISON CO. , LTD.		
当前申请(专利权)人(译)	三星MEDISON CO. , LTD.		
[标]发明人	DAFT CHRISTOPHER M W KIM HYOUNG JIN KIM KANG SIK LEE WOO YOUL		
发明人	DAFT, CHRISTOPHER M.W KIM, HYOUNG-JIN KIM, KANG-SIK LEE, WOO-YOUL		
IPC分类号	A61B8/14 A61B8/08 A61B8/00		
CPC分类号	A61B8/00 A61B8/08 A61B8/14 A61B8/463 A61B8/5215 A61B8/54 G01S7/52046 G01S7/5205 G01S7/52071 G01S7/52074 G01S15/8915 G16H50/20 A61B8/145 A61B8/4488 A61B8/5207 A61B8/5246 A61B8/5269		
优先权	62/180145 2015-06-16 US 1020160004413 2016-01-13 KR		
其他公开文献	EP3311752A1		
外部链接	Espacenet		

摘要(译)

提供一种超声波成像设备，包括探头，该探头被配置为沿着第一路径将超声信号发送到物体并接收从物体反射的回波信号;处理器，被配置为生成表示所述对象的第一超声图像，根据预定标准检测所生成的第一超声图像中的区域中的至少一个具有低图像质量的区域，通过聚焦控制所述超声信号沿第二路径传输超声信号在对应于检测到的至少一个区域的对象的预定区域内的焦点处，并且基于响应于沿着对象发送到对象的超声信号而接收的回波信号，生成表示对象的第二超声图像。第二条道路。