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(54) **Providing an ultrasound spatial compound image based on center lines of ultrasound images in an ultrasound system**

Bereitstellung eines räumlichen Ultraschall-Verbindungsbildes basierend auf Zentrumslinien von Ultraschallbildern in einem Ultraschallsystem

Fourniture d'une image composée spatiale d'ultrasons fondée sur les lignes centrales des images par ultrasons dans un système par ultrasons

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EP 2 444 821 B1

Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to ultrasound systems, and more particularly to providing an ultrasound spatial compound image based on center lines of ultrasound images in an ultrasound system.

BACKGROUND

[0002] An ultrasound system has become an important and popular diagnostic tool since it has a wide range of applications. Specifically, due to its non-invasive and non-destructive nature, the ultrasound system has been extensively used in the medical profession. Modern high-performance ultrasound systems and techniques are commonly used to produce two-dimensional or three-dimensional ultrasound images of internal features of a target object (e.g., human organs).

[0003] The ultrasound system may transmit and receive ultrasound signals to and from a living body to thereby form a 2D (two-dimensional) ultrasound image or a 3D (three-dimensional) ultrasound image. Various techniques have been studied to enhance resolution of the ultrasound image. Spatial compounding is known as one of such techniques.

[0004] The spatial compounding is an imaging technique for forming a compound image by combining ultrasound images. That is, the ultrasound system forms a plurality of ultrasound images and performs the spatial compounding upon the ultrasound images to form an ultrasound spatial compound image.

[0005] The ultrasound system disposes scan-lines set a virtual common point, at which a plurality of scan-lines intersect, and moves the virtual common point to a particular position to thereby set a plurality of scan-lines corresponding to each of the ultrasound images. However, there is a problem since a steering angle corresponding to a particular scan-line becomes very large and effects of spatial compounding in the center of an image display area for displaying an ultrasound image decrease.

[0006] The EP 1 903 353 A1 discloses an ultrasound system for forming an ultrasound image by using a plurality of sub-frames, comprising: a plurality of transducers for transmitting and receiving ultrasound signals along a plurality of scan lines to obtain sub-frames; a determination unit for locating a common point where extensions of said scan lines with respect to the transducers intersect, determine a plurality of virtual common points based on the located common point and determine a plurality of transducer groups, steering angles and a plurality of scan-line groups; a controller responsive to a change of the sub-frames to select scan lines corresponding to the changed sub-frame and adjust steering angles of the selected scan lines based on the plurality of transducer groups, the steering angles and the plurality of scan-line groups; and a processor for synthesizing the plurality of sub-frames to form an ultrasound image.

[0007] The EP 1 906 207 A1 discloses embodiments providing an apparatus and method for forming an ultrasound image, wherein an ultrasound signal is transmitted and received along a scan line determined based on a virtual common point at each of a plurality of transducers. In accordance with an embodiment of the present invention, the image frames (as many as desired) for forming a composite image may be obtained, thereby ultimately causing the quality of the ultrasound image to be enhanced.

[0008] The US 6 814 701 B1 discloses a method for reducing noise in ultrasound images comprising the steps of transmitting and receiving from an ultrasound transducer comprising a plurality of apexes a plurality of ultrasound beams from a first apex to form a first sector image comprising a plurality of image intensities, transmitting and receiving from at least one other apex of the transducer a plurality of ultrasound beams to form at least one other sector image comprising a plurality of image intensities overlapping a portion of the first sector image to form an overlap region, and combining the first sector image and the at least one other sector image to produce a compound image.

[0009] The US 2009/069681 A1 discloses a system and method which makes a phased array look like a curved array for purposes of performing spatial compounding calculations. In one embodiment, the phased array is treated as though it were a curved array by creating both a virtual apex and a virtual radius of curvature. Based on this transformation, standard spatial-compounding resampling tables can be used just as they are with curved arrays. In one embodiment, after the data is compounded to form the target image, certain data is removed prior to the actual display. This removed data represents data generated by virtual rays the prior to the physical skin line of the phased array.

[0010] In the US 2004/054284 A1 an image formed from compounded frames of ultrasound data acquired with different steering angles is displayed. Each component frame is associated with a scan of the entire displayed region. A majority of scan lines for each component frame are pointed in one direction or the same relative direction, and a minority of the scan lines are steered at different angles within each component frame to scan the rest of the display region, but with a different steering angle for the majority of scan lines of each of the component frames. As a result, the benefits of spatial compounding component frames associated with different steering angles are provided without having to apply filtering to reduce line artifacts.

[0011] The US 2004/225218 A1 discloses methods and systems for identifying clinical markers in spatial compounded imaging. For example, an image responsive to less spatial compounding more likely preserves clinical markers than a steered compound image. By displaying both images, clinical markers are identified by the user from one image and other diagnostic information is obtained from the steered compound image. As another example, clinical marker information is identified and added back into or highlighted on a spatial compound image for identification by the user.

SUMMARY

[0012] Embodiments for providing an ultrasound spatial compound image in an ultrasound system are disclosed herein. In one embodiment an ultrasound system comprises the features of claim 1.

[0013] In another embodiment, there is a method of providing an ultrasound spatial compound image comprising the features of claim 6.

[0014] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a block diagram showing an illustrative embodiment of an ultrasound system.

FIG. 2 is a block diagram showing an illustrative embodiment of an ultrasound data acquisition unit.

FIG. 3 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a first embodiment.

FIG. 4 is a schematic diagram showing an example of a plurality of scan-lines and a virtual common point.

FIG. 5 is a schematic diagram showing an example of setting center lines in accordance with the first embodiment.

FIG. 6 is a schematic diagram showing an example of sub-virtual common points and ultrasound images in accordance with the first embodiment.

FIG. 7 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a second embodiment.

FIG. 8 is a schematic diagram showing an example of setting center lines in accordance with the second embodiment.

FIG. 9 is a schematic diagram showing an example of sub-virtual common point and ultrasound images in accordance with the second embodiment.

FIG. 10 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a third embodiment.

FIG. 11 is a schematic diagram showing an example of center lines, sub-virtual common points and ultrasound images in accordance with the third embodiment.

DETAILED DESCRIPTION

[0016] A detailed description may be provided with reference to the accompanying drawings. One of ordinary skill in the art may realize that the following description is illustrative only and is not in any way limiting.

First Embodiment

[0017] Referring to FIG. 1, an ultrasound system 100 in accordance with an illustrative embodiment is shown. As depicted therein, the ultrasound system 100 includes an ultrasound data acquisition unit 110. The ultrasound data acquisition unit 110 is configured to transmit and receive ultrasound signals to and from a living body and output ultrasound data. The living body includes a plurality of target objects (e.g., blood vessels, a heart, etc.). FIG. 2 is a block diagram showing an illustrative embodiment of the ultrasound data acquisition unit 110. Referring to FIG. 2, the ultrasound data acquisition unit 110 includes an ultrasound probe 210. The ultrasound probe 210 includes a plurality of elements 211 (*see* FIG. 4) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe 210 is configured to transmit ultrasound signals to the living body along each of the scan-lines. The ultrasound probe 210 is further configured to receive ultrasound signals (i.e., ultrasound echo signals) from the living body to output received signals. The received signals are analog signals. The ultrasound probe 210 includes a convex probe.

[0018] The ultrasound data acquisition unit 110 further includes a transmit (Tx) signal generating section 220. The Tx signal generating section 220 is configured to control the transmission of the ultrasound signals. The Tx signal generating section 220 is further configured to generate electrical signals ("Tx signals") for obtaining at least one ultrasound image in consideration of the elements and focal points. The ultrasound image includes a brightness mode image. However, it should be noted herein that the ultrasound image may not be limited thereto.

In one embodiment, the Tx signal generating section 220 is configured to generate first Tx signals for obtaining a first ultrasound image SF_1, as shown in FIG. 6. Thus, the ultrasound probe 210 is configured to convert the first Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output first received signals. The Tx signal generating section 220 is further configured to generate second Tx signals for obtaining a second ultrasound image SF_2, as shown in FIG. 6. Thus, the ultrasound probe 210 is configured to convert the second Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output second received signals. The Tx signal generating section 220 is further configured to generate third Tx signals for obtaining a third ultrasound image SF_3, as shown in FIG. 6.

Thus, the ultrasound probe 210 is configured to convert the third Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output third received signals.

The number of ultrasound images is determined depending on the number of the ultrasound images, which are needed to form an ultrasound spatial compound image.

[0019] The ultrasound data acquisition unit 110 further includes a beam former 230. The beam former 230 is configured to convert the received signals provided from the ultrasound probe 210 into digital signals. The beam former 230 is further configured to apply delays to the digital signals in consideration of the elements and the focal points to thereby output digital receive-focused signals.

[0020] In one embodiment, the beam former 230 is configured to convert the first received signals provided from the ultrasound probe 210 into first digital signals. The beam former 230 is further configured to apply delays to the first digital signals in consideration of the elements and the focal points to thereby output first digital receive-focused signals. The beam former 230 is further configured to convert the second received signals provided from the ultrasound probe 210 into second digital signals. The beam former 230 is further configured to apply delays to the second digital signals in consideration of the elements and the focal points to thereby output second digital receive-focused signals. The beam former 230 is further configured to convert the third received signals provided from the ultrasound probe 210 into third digital signals. The beam former 230 is further configured to apply delays to the third digital signals in consideration of the elements and the focal points to thereby output third digital receive-focused signals.

[0021] The ultrasound data acquisition unit 110 further includes an ultrasound data forming section 240. The ultrasound data forming section 240 is configured to form ultrasound data corresponding to the ultrasound image based on the digital receive-focused signals provided from the beam former 230. The ultrasound data include radio frequency data. However, it should be noted herein that the ultrasound data may not be limited thereto. The ultrasound data forming section 240 is further configured to perform signal processing (e.g., gain control, etc) upon the digital receive-focused signals.

[0022] In one embodiment, the ultrasound data forming section 240 is configured to form first ultrasound data corresponding to the first ultrasound image SF_1 based on the first digital receive-focused signals provided from the beam former 230. The ultrasound data forming section 240 is further configured to form second ultrasound data corresponding to the second ultrasound image SF_2 based on the second digital receive-focused signals provided from the beam former 230. The ultrasound data forming section 240 is further configured to form third ultrasound data corresponding to the third ultrasound image SF_3 based on the third digital receive-focused signals provided from the beam former 230.

[0023] Alternatively, the ultrasound data acquisition unit 110 is further configured to acquire the ultrasound data from an external or internal storage unit (not shown) connected to the ultrasound system 100.

[0024] Referring back to FIG. 1, the ultrasound system 100 further includes a processing unit 120 in communication with the ultrasound data acquisition unit 110. The processing unit 120 includes a central processing unit, a microprocessor or a graphic processing unit. However, it should be noted herein that the processing unit 120 may not be limited thereto.

[0025] FIG. 3 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a first embodiment. The processing unit 120 is configured to set a virtual common point VP corresponding to scan-lines S_1 to S_N in consideration of positions of the elements 211 as shown in FIG. 4, at step S302 in FIG. 3. The virtual common point VP is a point at which the scan-lines S_1 to S_N intersect by extending the scan-lines S_1 to S_N to back of the elements 211.

The processing unit 120 is configured to set center lines corresponding to the ultrasound images based on the virtual common point VP, at step S304 in FIG. 3. Herein, the center lines converge into the virtual common point VP. Each of the ultrasound images includes a part of an image display area. The image display area is an area capable of displaying an ultrasound image without steering the scan-lines S_1 to S_N.

[0026] In one embodiment, the processing unit 120 is configured to set a first center line CL_1 corresponding to the first ultrasound image SF_1, which includes a part of the image display area IDA, based on the virtual common point VP, as shown in FIG. 5. The processing unit 120 is further configured to set a second center line CL_2 corresponding to the second ultrasound image SF_2, which includes a part of the image display area IDA, based on the virtual common point VP, as shown in FIG. 5. The processing unit 120 is further configured to set a third center line CL_3 corresponding to the third ultrasound image SF_3, which includes a part of the image display area IDA, based on the virtual common point VP, as shown in FIG. 5. Angles between adjacent center lines are same or different. That is, an angle between the first center line CL_1 and the second center line CL_2 and an angle between the first center line CL_1 and the third center line CL_3 are same or different.

[0027] The number of center lines is determined depending on the number of the ultrasound images to be compounded.

[0028] The processing unit 120 is configured to set virtual common point moving positions corresponding to the center lines based on the virtual common point VP, at step S306 in FIG. 3. The virtual common point moving position is a position for moving the virtual common point VP to a predetermined distance along a center line in order to form an ultrasound image corresponding to the center line. The processing unit 120 is configured to move the virtual common point VP to the virtual common point moving positions to set sub-virtual common points corresponding to the ultrasound images, at step S308 in FIG. 3.

[0029] The processing unit 120 is configured to set a first virtual common point moving position for moving the virtual common point VP along the first center line CL_1. The processing unit 120 is further configured to move the virtual common point VP to the first virtual common point moving position to set a first sub-virtual common point SVP_1 corresponding to the first ultrasound image SF_1, as shown in FIG. 6. The processing unit 120 is further configured to set a second virtual common point moving position for moving the virtual common point VP along the second center line CL_2. The processing unit 120 is further configured to move the virtual common point VP to the second virtual common point moving position to set a second sub-virtual common point SVP_2 corresponding to the second ultrasound image SF_2, as shown in FIG. 6. The processing unit 120 is further configured to set a third virtual common point moving position for moving the virtual common point VP along the third center line CL_3. The processing unit 120 is further configured to move the virtual common point VP to the third common point moving position to set a third sub-virtual common point SVP_3 corresponding to the third ultrasound image SF_3, as shown in FIG. 6.

[0030] The processing unit 120 is configured to set a plurality of scan-lines corresponding to each of the ultrasound images based on the virtual common point, the sub-virtual common points and the center lines, at step S310 in FIG. 3. Thus, the ultrasound data acquisition unit 110 is configured to transmit the ultrasound signals to the living body along the scan-lines and receive the ultrasound echo signals from the living body to acquire the ultrasound data corresponding to each of the ultrasound images.

[0031] As one example, the processing unit 120 is configured to set a reference ultrasound image from the ultrasound images SF_1 to SF_3. The processing unit 120 sets the first ultrasound image SF_1 as the reference ultrasound image. The processing unit 120 is further configured to detect an element corresponding to the second center line CL_2 from the plurality of elements 211 based on the reference ultrasound image. That is, the processing unit 120 detects the element, through which the second center line CL_2 adjacent to the first center line CL_1 corresponding to the reference ultrasound image (i.e., first ultrasound image SF_1) passes.
The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the element based on the first sub-virtual common point SVP_1 corresponding to the reference ultrasound image, as a reference scan-line (i.e., first scan-line) of the first ultrasound image SF_1. The processing unit 120 is further configured to set a plurality of scan-lines (i.e., steering angles corresponding to of the scan-lines) corresponding to the first ultrasound image SF_1 based on the first scan-line of the first ultrasound image SF_1. The methods of setting the scan-lines based on the first scan-line are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. The processing unit 120 is further configured to rotate the first center line CL_1 to the second center line CL_2 based on the virtual common point VP to set a plurality of scan-lines corresponding to the second ultrasound image SF_2. The processing unit 120 is also configured to rotate the first center line CL_1 to the second center line CL_3 based on the virtual common point VP to set a plurality of scan-lines corresponding to the third ultrasound image SF_3.

[0032] As another example, the processing unit 120 is configured to set a reference ultrasound image from the ultrasound images SF_1 to SF_3. The processing unit 120 sets the first ultrasound SF_1 as the reference ultrasound image. The processing unit 120 is further configured to detect an element corresponding to the second center line CL_2 from the plurality of elements 211 based on the reference ultrasound image. That is, processing unit 120 detects the element, through which the second center line CL_2 adjacent to the first center line CL_1 corresponding to the reference ultrasound image passes. The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is also configured to set a scan-line, which passes through the center point of the element on a basis of the first sub-virtual common point SVP_1 corresponding the reference ultrasound image, as a reference scan-line (i.e., last scan-line) of the first ultrasound image SF_1 (i.e., reference ultrasound image). The processing unit 120 is further configured to rotate the first center line CL_1 to second center line CL_2 based on the virtual common point VP to set a plurality of scan-lines corresponding to the second ultrasound image SF_2. The processing unit 120 is additionally configured to rotate the first center line CL_1 to the third center line CL_3 based on the virtual common point VP to set a plurality of scan-lines corresponding to the third ultrasound image SF_3.

[0033] As yet another embodiment, the processing unit 120 is configured to set a reference ultrasound image from the ultrasound images SF_1 to SF_3. The processing unit 120 sets the first ultrasound image SF_1 as the reference ultrasound image. The processing unit 120 is further configured to detect a center point of a first element from the plurality of elements 211. The processing unit 120 is also configured to set a scan-line, which passes through the center point of the first element on a basis of the first sub-virtual common point SVP_1, as a reference scan-line (i.e., first scan-line) of the reference ultrasound image. The processing unit 120 is configured to calculate an angle between the first scan-line S_1 shown in FIG. 4 and the first scan-line of the reference ultrasound image. That is, the processing unit 120 calculates a steering angle of the scan-line S_1 shown in FIG. 4 when the virtual common point VP is moved to the first sub-virtual common point SVP_1. The processing unit 120 is further configured to determine whether the calculated angle exists within a predetermined range (e.g., 0 < range ≤ a maximum directivity angle of the ultrasound probe 210). If it is determined that the calculated angle does not exist within the predetermined range, then the processing unit 120 is further configured to detect a center point of a second element from the plurality of elements 211. The processing unit 120 is also configured to set a scan-line, which passes through the center point of the second element based on the first sub-virtual common point SVP_1, as a first scan-line of the reference ultrasound image (i.e., first ultrasound image SF_1). The processing unit 120 is further configured to calculate an angle between the scan-line S_2 shown in FIG. 4 and the first scan-line of the reference ultrasound image. That is, the processing unit 120 calculates a steering angle of the scan-line S_2 shown in FIG. 4 when the virtual common point VP is moved to the first sub-virtual common point SVP_1. The processing unit 120 is further configured to determine whether the calculated angle exists within the predetermined range.

If it is determined that the calculated angle exists within the predetermined range, then the processing unit 120 is further configured to set a plurality of scan-lines (i.e., steering angles corresponding to the scan-lines) of the reference ultrasound image (i.e., first ultrasound image SF_1) based on the first scan-line of the reference ultrasound image. The processing unit 120 is further configured to rotate the first center line CL_1 to second center line CL_2 based on the virtual common point VP to set a plurality of scan-lines corresponding to the second ultrasound image SF_2. The processing unit 120 is further configured to rotate the first center line CL_1 to the third center line CL_3 based on the virtual common point VP to set a plurality of scan-lines corresponding to the third ultrasound image SF_3.

[0034] Although it is described that the processing unit 120 is configured to set the plurality of scan-lines corresponding to the first ultrasound image based on the first element of the elements 211 and the first scan-line of the first ultrasound image, the processing unit 120 is further configured to set the plurality of scan-lines corresponding to the first ultrasound image based on the first element of the elements 211 and a last scan-line of the first ultrasound image.

[0035] The processing unit 120 is configured to form the ultrasound images based on the ultrasound data provided from the ultrasound data acquisition unit 110, at step S312 in FIG. 3.

[0036] In one embodiment, the processing unit 120 is configured to form the first ultrasound image SF_1 based on the first ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 6. The processing unit 120 is further configured to form the second ultrasound image SF_2 based on the second ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 6. The processing unit 120 is further configured to form the third ultrasound image SF_3 based on the third ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 6.

[0037] The processing unit 120 is configured to perform spatial compounding upon the ultrasound images to form an ultrasound spatial compound image, at step S314 in FIG. 3. The methods of performing the spatial compounding are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. For example, the processing unit 120 performs the spatial compounding by calculating a mean brightness value corresponding to each of the pixels of the ultrasound images.

[0038] Referring back to FIG. 1, the ultrasound system 100 further includes a storage unit 130. The storage unit 130 stores the ultrasound data acquired by the ultrasound data acquisition unit 110. The storage unit 130 further stores the ultrasound images formed by the processing unit 120.

[0039] The ultrasound system 100 further includes a display unit 140. The display unit 140 is configured to display the ultrasound spatial compound image. The display unit 140 is also configured to display the ultrasound images.

Second Embodiment

[0040] Referring to FIG. 2, the ultrasound probe 210 includes the plurality of elements 211 (see FIG. 4) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe 210 is configured to transmit the ultrasound signals to the living body along the scan-lines. The ultrasound probe 210 is further configured to receive the ultrasound echo signals from the living body to output the received signals.

[0041] The Tx signal generating section 220 is configured to control the transmission of the ultrasound signals. The Tx signal generating section 220 is further configured to generate the Tx signals for obtaining at least one ultrasound image in consideration of the elements and the focal points.

[0042] The Tx signal generating section 220 is configured to generate first Tx signals for obtaining a first ultrasound image SF_1, as shown in FIG. 9. Thus, the ultrasound probe 210 is configured to convert the first Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output first received signals. The Tx signal generating section 220 is further configured to generate second Tx signals for obtaining a second ultrasound image SF_2, as shown in FIG.

9. Thus, the ultrasound probe 210 is configured to convert the second Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output second received signals. The Tx signal generating section 220 is further configured to generate third Tx signals for obtaining a third ultrasound image SF_3, as shown in FIG. 9. Thus, the ultrasound probe 210 is configured to convert the third Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output third received signals.

[0043] The beam former 230 is configured to convert the received signals provided from the ultrasound probe 210 into digital signals. The beam former 230 is further configured to apply delays to the digital signals in consideration of the elements and the focal points to thereby output digital receive-focused signals.

[0044] In one embodiment, the beam former 230 is configured to convert the first received signals provided from the ultrasound probe 210 into first digital signals. The beam former 230 is further configured to apply delays to the first digital signals in consideration of the elements and the focal points to thereby output first digital receive-focused signals. The beam former 230 is further configured to convert the second received signals provided from the ultrasound probe 210 into second digital signals. The beam former 230 is also configured to apply delays to the second digital signals in consideration of the elements and the focal points to thereby output second digital receive-focused signals. The beam former 230 is further configured to convert the third received signals provided from the ultrasound probe 210 into third digital signals. The beam former 230 is also configured to apply delays to the third digital signals in consideration of the elements and the focal points to thereby output third digital receive-focused signals.

[0045] The ultrasound data forming section 240 is configured to form ultrasound data based on the digital receive-focused signals provided from the beam former 230. The ultrasound data include radio frequency data. However, it should be noted herein that the ultrasound data may not be limited thereto. The ultrasound data forming section 240 is further configured to perform signal processing (e.g., gain control, etc) upon the digital receive-focused signals.

[0046] The ultrasound data forming section 240 is configured to form first ultrasound data corresponding to the first ultrasound image SF_1 shown in FIG. 9 based on the first digital receive-focused signals provided from the beam former 230. The ultrasound data forming section 240 is further configured to form second ultrasound data corresponding to the second ultrasound image SF_2 shown in FIG. 9 based on the second digital receive-focused signals provided from the beam former 230. The ultrasound data forming section 240 is also configured to form third ultrasound data corresponding to the third ultrasound image SF_3 shown in FIG. 9 based on the third digital receive-focused signals provided from the beam former 230.

FIG. 7 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a second embodiment. The processing unit 120 is configured to set the virtual common point VP corresponding to the scan-lines S_1 to S_N in consideration of positions of the elements 211 as shown in FIG. 4, at step S702 in FIG. 7.

[0047] The processing unit 120 is configured to set center lines corresponding to the ultrasound images based on the virtual common point VP, at step S704 in FIG. 7.

[0048] In one embodiment, the processing unit 120 is configured to set a first center line CL_1 corresponding to the first ultrasound image SF_1, which includes the image display area IDA, based on the virtual common point VP as shown in FIG. 8. The processing unit 120 is further configured to set a second center line CL_2 corresponding to the second ultrasound image SF_2, which includes a part of the image display area IDA, based on the virtual common point VP, as shown in FIG. 8. The processing unit 120 is also configured to set a third center line CL_3 corresponding to the third ultrasound image SF_3, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 8. Angles between adjacent center lines are same or different. That is, an angle between the first center line CL_1 and the second center line CL_2 and an angle between the first center line CL_1 and the third center line CL_3 are same or different.

[0049] The number of center lines is determined depending on the number of the ultrasound images to be compounded.

[0050] The processing unit 120 is configured to set virtual common point moving positions corresponding to the center lines based on the virtual common point VP, at step S706 in FIG. 7. The processing unit 120 is configured to move the virtual common point VP to the virtual common point moving positions to set sub-virtual common points corresponding to the ultrasound images, at step S708 in FIG. 7.

[0051] In one embodiment, the processing unit 120 is configured to set a first virtual common point moving position for moving the virtual common point VP along the first center line CL_1. The first virtual common point moving position corresponds to the virtual common point VP. That is, the processing unit 120 sets the first virtual common point moving position, to which the virtual common point VP is not moved, in order to obtain the first ultrasound image SF_1. The first ultrasound image SF_1 is set as a reference ultrasound image. The processing unit 120 is further configured to set a second virtual common point moving position for moving the virtual common point VP along the second center line CL_2. The processing unit 120 is also configured to move the virtual common point VP to the second virtual common point moving position to set a second sub-virtual common point SVP_2 corresponding to the second ultrasound image SF_2, as shown in FIG. 8. The processing unit 120 is further configured to set a third virtual common point moving position for moving the virtual common point VP along the center line CL_3. The processing unit 120 is further configured to move the virtual common point VP to the third virtual common point moving position to set a third sub-virtual common point SVP_3 corresponding to the third ultrasound image SF_3, as shown in FIG. 8. The processing unit 120 is configured to set a plurality of scan-lines corresponding to each of the ultrasound images based on the virtual common point, the sub-virtual common points and the center lines, at step S710 in FIG. 7. Thus, the ultrasound data acquisition unit 110 is configured to transmit the ultrasound signals to the living body along the scan-lines and receive the ultrasound echo signals from the living body to acquire the ultrasound data corresponding to each of the ultrasound images.

[0052] As one example, the processing unit 120 is configured to set a plurality of scan-lines corresponding to the first ultrasound image SF_1 based on the virtual common point VP. The scan-lines of the first ultrasound image SF_1 correspond to the scan-lines S_1 to S_N shown in FIG. 4. The processing unit 120 is further configured to detect an element corresponding to the second center line CL_2 from the plurality of elements 211. That is, the processing unit 120 detects the element, through which the second center line CL_2 passes, from the plurality of elements 211. The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is also configured to rotate the second center line CL_2 to the first center line CL_1 based on the virtual common point VP. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the element, as a first scan-line of the second ultrasound image SF_2 based on the second sub-virtual common point SVP_2. The processing unit 120 is also configured to set a plurality of scan-lines (i.e., steering angles corresponding to the scan-lines) corresponding to the second ultrasound image SF_2 based on the first scan-line of the second ultrasound image SF_2. The methods of setting the scan-lines based on the first scan-line are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. The processing unit 120 is further configured to reconvey the second center line CL_2 based on the virtual common point VP. The processing unit 120 is further configured to detect an element corresponding to the third center line CL_3 from the plurality of elements 211. That is, the processing unit 120 detects the element, through which the third center line CL_3 passes, from the plurality of elements 211. The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is also configured to rotate the third center line CL_3 to the first center line CL_1 based on the virtual common point VP. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the element as a first scan-line of the third ultrasound image SF_3 based on the third sub-virtual common point SVP_3. The processing unit 120 is further configured to set a plurality of scan-lines (i.e., steering angles corresponding to the scan-lines) corresponding to the third ultrasound image SF_3 based on the first scan-line of the third ultrasound image SF_3. The processing unit is configured to reconvey the third center line CL_3 based on the virtual common point VP.

[0053] As another example, the processing unit 120 is configured to set a plurality of scan-lines corresponding to the first ultrasound image SF_1 based on the virtual common point VP. The scan-lines of the first ultrasound image SF_1 correspond to the scan-lines S_1 to S_N shown in FIG. 4. The processing unit 120 is further configured to detect an element corresponding to the second center line CL_2 from the plurality of elements 211. That is, the processing unit 120 detects the element, through which the second center line CL_2 passes, from the plurality of elements 211. The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is further configured to rotate the second center line CL_2 to the first center line CL_1 based on the virtual common point VP. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the element, as a reference scan-line (i.e., last scan-line) of the second ultrasound image SF_2 based on the second sub-virtual common point SVP_2. The processing unit 120 is further configured to set a plurality of scan-lines (i.e., steering angles corresponding to the scan-lines) corresponding to the second ultrasound image SF_2 based on the last scan-line of the second ultrasound image SF_2. The methods of setting the scan-lines based on the last scan-line are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. The processing unit 120 is further configured to reconvey the second center line CL_2 based on the virtual common point VP. The processing unit 120 is further configured to detect an element corresponding to the third center line CL_3 from the plurality of elements 211. That is, the processing unit 120 detects the element, through which the third center line CL_3 passes, from the plurality of elements 211. The processing unit 120 is further configured to detect a center point of the element. The processing unit 120 is also configured to rotate the third center line CL_3 to first center line CL_1 based on the virtual common point VP. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the element as a last scan-line of the third ultrasound image SF_3 based on the third sub-virtual common point SVP_3. The processing unit 120 is further configured to set a plurality of scan-lines (i.e., steering angles corresponding to the scan-lines) corresponding to the third ultrasound image SF_3 based on the last scan-line of the third ultrasound image SF_3. The processing unit 120 is further configured to reconvey the third center line CL_3

based on the virtual common point VP.

[0054] As yet another example, the processing unit 120 is configured to set a plurality of scan-lines corresponding to the first ultrasound image SF_1 based on the virtual common point VP. The scan-lines of the first ultrasound image SF_1 correspond to the scan-lines S_1 to S_N shown in FIG. 4. The processing unit 120 is further configured to rotate the second center line CL_2 to the first center line CL_1 based on the virtual common point VP. The processing unit 120 is further configured to detect a center point of a first element from the plurality of elements 211. The processing unit 1120 is further configured to set a scan-line, which passes through the center point of the first element, as a reference scan-line (i.e., first scan-line) of the second ultrasound image SF_2 based on the second sub-virtual common point SVP_2. The processing unit 120 is further configured to calculate an angle between the scan-line S_1 shown in FIG. 4 and the first scan-line of the second ultrasound image SF_2. The processing unit 120 is further configured to determine whether the calculated angle exists within a predetermined range (e.g., 0 < range ≤ a maximum directivity angle of the ultrasound probe 210). If it is determined that the calculated angle does not exist within the predetermined range, then the processing unit 120 is further configured to detect a center point of a second element from the plurality of elements 211. The processing unit 120 is further configured to set a scan-line, which passes through the center point of the second element on a basis of the second sub-virtual common point SVP_2, as the first scan-line of the second ultrasound image SF_2. The processing unit 120 is also configured to calculate an angle between the scan-line S_2 shown in FIG. 4 and the first scan-line of the second ultrasound image SF_2. The processing unit 120 is further configured to determine whether the calculated angle exists within the predetermined range. If it is determined that the calculated angle exists within the predetermined angle, then the processing unit 120 is further configured to set a plurality of scan-lines corresponding to the second ultrasound image SF_2 based on the first scan-line of the second ultrasound image SF_2. The processing unit 120 is further configured to set a plurality of scan-lines corresponding to the third ultrasound image SF_3, as mentioned above.

[0055] Although it is described that the processing unit 120 is configured to set the plurality of scan-lines based on the first element and the first scan-line, the processing unit 120 is further configured to set the plurality of scan-lines based on a last element and a last scan-line.

[0056] The processing unit 120 is configured to set rotating angles corresponding to the center lines, at step S712 in FIG. 7. The rotating angle is an angle for the ultrasound images including the part of the image display area IDA into the image display area IDA.

[0057] In one embodiment, the processing unit 120 is configured to set a first rotating angle corresponding to the first center line CL_1 based on the first sub-virtual common point (i.e., virtual common point VP). The first rotating angle is an angle for rotating the first ultrasound image SF_1 into the image display area IDA based on the first sub-virtual common point, and is 0. The processing unit 120 is further configured to set a second rotating angle θ_2 corresponding to the second center line CL_2 based on the second sub-virtual common point SVP_2 as shown in FIG. 8. The second rotating angle θ_2 is an angle for rotating the second ultrasound image SF_2 into the image display area IDA based on the second sub-virtual common point SVP_2. The processing unit 120 is further configured to set a third rotating angle θ_2 corresponding to the third center line CL_3 based on the third sub-virtual common point SVP_3 as shown in FIG. 8. The third rotating angle θ_3 is an angle for rotating the third ultrasound image SF_3 into the image display area IDA based on the third sub-virtual common point SVP_3.

The processing unit 120 is configured to rotate the ultrasound images into the image display area IDA based on the rotating angles and the sub-virtual common points, at step S714 in FIG. 7.

[0058] In one embodiment, the processing unit 120 is configured to rotate the second center line CL_2 to a new second center line CL_2' corresponding to the second rotating angle θ_2 based on the second sub-virtual common point SVP_2, as shown in FIG. 9. Thus, the second ultrasound image SF_2 is rotated into the image display area IDA, as shown in FIG. 9. The processing unit 120 is further configured to rotate the third center line CL_3 to a new third center line CL_3' corresponding to the third rotating angle θ_3 based on the third sub-virtual common point SVP_3, as shown in FIG. 9. Thus, the third ultrasound image SF_3 is rotated into the image display area IDA, as shown in FIG. 9.

[0059] The processing unit 120 is configured to reset a plurality of scan-lines corresponding to each of the ultrasound images based on the rotating angles, at step S716 in FIG. 7. Thus, the ultrasound data acquisition unit 110 is configured to transmit the ultrasound signals to the living body along the reset scan-lines and receive the ultrasound echo signals from the living body to thereby acquire the ultrasound data corresponding to each of the ultrasound images. In one embodiment, the processing unit 120 is configured to reset the plurality of scan-lines corresponding to the second ultrasound image SF_2, which is rotated into the image display area IDA based on the second rotating angle θ_2. The processing unit 120 is further configured to reset the plurality of scan-lines corresponding to the third ultrasound image SF_3, which is rotated into the image display area IDA based on the third rotating angle θ_3.

The processing unit 120 is configured to form the ultrasound images based on the ultrasound data provided from the ultrasound data acquisition unit 110, at step S718 in FIG. 7.

In one embodiment, the processing unit 120 is configured to form the first ultrasound image SF_1 based on the first ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 9. The processing unit 120 is further configured to form the second ultrasound image SF_2 based on the second ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 9. The processing unit 120 is further configured to form the third ultrasound image SF_3 based on the third ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 9.

The processing unit 120 is configured to perform spatial compounding upon the ultrasound images to form an ultrasound spatial compound image, at step S720 in FIG. 7. The methods of performing the spatial compounding are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. For example, the processing unit 120 performs the spatial compounding by calculating a mean brightness value corresponding to each of the pixels of the ultrasound images.

Example useful for understanding the invention

[0060] Referring to FIG. 2, the ultrasound probe 210 includes a plurality of elements 211 (*see* FIG. 4) for reciprocally converting between ultrasound signals and electrical signals. The ultrasound probe 210 is configured to transmit ultrasound signals to the living body along the scan-lines. The ultrasound probe 210 is further configured to receive ultrasound signals (i.e., ultrasound echo signals) from the living body to output received signals. The received signals are analog signals. The ultrasound probe 210 includes a wide view angle probe. However, it should be noted herein that the ultrasound probe 210 may not be limited thereto.

The Tx signal generating section 220 is configured to control the transmission of the ultrasound signals. The Tx signal generating section 220 is further configured to generate the Tx signals for obtaining at least one ultrasound image in consideration of the elements and the focal points.

[0061] In one example, the Tx signal generating section 220 is configured to generate first Tx signals for obtaining a first ultrasound image SF_1 shown in FIG. 11. Thus, the ultrasound probe 210 is configured to convert the first Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output first received signals. The Tx signal generating section 220 is further configured to generate second Tx signals for obtaining a second ultrasound image SF_2 shown in FIG. 11. Thus, the ultrasound probe 210 is configured to convert the second Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output second received signals. The Tx signal generating section 220 is further configured to generate third Tx signals for obtaining a third ultrasound image SF_3 shown in FIG. 11. As such, the ultrasound probe 210 is configured to convert the third Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output third received signals. The Tx signal generating section 220 is further configured to generate fourth Tx signals for obtaining a fourth ultrasound image SF_4 shown in FIG. 11. Thus, the ultrasound probe 210 is configured to convert the fourth Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to living body and receive the ultrasound echo signals from the living body to thereby output fourth received signals. The Tx signal generating section 220 is further configured to generate fifth Tx signals for obtaining a fifth ultrasound image SF_5 shown in FIG. 11. Accordingly, the ultrasound probe 210 is configured to convert the fifth Tx signals provided from the Tx signal generating section 220 into the ultrasound signals, transmit the ultrasound signals to the living body and receive the ultrasound echo signals from the living body to thereby output fifth received signals.

The beam former 230 is configured to convert the received signals provided from the ultrasound probe 210 into digital signals. The beam former 230 is further configured to apply delays to the digital signals in consideration of the elements and the focal points to thereby output digital receive-focused signals.

[0062] In one example, the beam former 230 is configured to convert the first received signals provided from the ultrasound probe 210 into first digital signals. The beam former 230 is further configured to apply delays to the first digital signals in consideration of the elements and the focal points to thereby output first digital receive-focused signals. The beam former 230 is further configured to convert the second received signals provided from the ultrasound probe 210 into second digital signals. The beam former 230 is further configured to apply delays to the second digital signals in consideration of the elements and the focal points to thereby output second digital receive-focused signals. The beam former 230 is further configured to convert the third received signals provided from the ultrasound probe 210 into third digital signals. The beam former 230 is also configured to apply delays to the third digital signals in consideration of the elements and the focal points to thereby output third digital receive-focused signals. The beam former 230 is further configured to covert the fourth received signals provided from the ultrasound probe 210 into fourth digital signals. The beam former 230 is further configured to apply delays to the fourth digital signals in consideration of the elements and the focal points to thereby output fourth digital receive-focused signals. The beam former 230 is additionally configured to convert the fifth received signals provided from the ultrasound probe 210 into fifth digital signals. The beam former 230 is further configured to apply delays to the fifth digital signals in consideration of the elements and the focal points to thereby output fifth digital receive-focused signals.

The ultrasound data forming section 240 is configured to form ultrasound data based on the digital receive-focused signals provided from the beam former 230. The ultrasound data include radio frequency data. However, it should be noted herein that the ultrasound data may not be limited thereto. The ultrasound data forming section 240 is further configured to perform the signal processing (e.g., gain control, etc) upon the digital receive-focused signals.

[0063] In one example, the ultrasound data forming section 240 is configured to form first ultrasound data corresponding to the first ultrasound image SF_1 shown in FIG. 11 based on the first digital receive-focused signals. The ultrasound data forming section 240 is further configured to form second ultrasound data corresponding to the second ultrasound image SF_2 shown in FIG. 11 based on the second digital receive-focused signals. The ultrasound data forming section 240 is also configured to form third ultrasound data corresponding to the third ultrasound image SF_3 shown in FIG. 11 based on the third digital receive-focused signals. The ultrasound data forming section 240 is further configured to form fourth ultrasound data corresponding to the fourth ultrasound image SF_4 shown in FIG. 11 based on the fourth digital receive-focused signals. The ultrasound data forming section 240 is configured to form fifth ultrasound data corresponding to fifth ultrasound image SF_5 shown in FIG. 11 based on the fifth digital receive-focused signals.

[0064] FIG. 10 is a flow chart showing a process of forming an ultrasound spatial compound image in accordance with a third embodiment. The processing unit 120 is configured to set the virtual common point VP corresponding to the scan-lines S_1 to S_N in consideration of positions of the elements 211 as shown in FIG. 4, at step S1002 in FIG. 10.

[0065] The processing unit 120 is configured to center lines corresponding to the ultrasound images on a basis of the virtual common point VP, at step S1004 in FIG. 10. In one embodiment, the processing unit 120 is configured to set a first center line CL_1 corresponding to the first ultrasound image SF_1, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 11. The processing unit 120 is further configured to set a second center line CL_2 corresponding to the second ultrasound image SF_2, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 11. The processing unit 120 is further configured to set a third center line CL_3 corresponding to the third ultrasound image SF_3, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 11. The processing unit 120 is also configured to set a fourth center line CL_4 corresponding to the fourth ultrasound image SF_4, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 11. The processing unit 120 is further configured to set a fifth center line CL_5 corresponding to the fifth ultrasound image SF_5, which includes a part of the image display area IDA, based on the virtual common point VP as shown in FIG. 11. Angles between the adjacent center lines are same or different. That is, an angle between the first center line CL_1 and the second center line CL_2, an angle between the second center line CL_2 and the third center line CL_3, an angle between the first center line CL_1 and the fourth center line CL_4, and an angle between the fourth center line CL_4 and the fifth center line CL_5 are be same or different.

[0066] The number of ultrasound images is determined depending on the number of the ultrasound images to be compounded.

[0067] The processing unit 120 is configured to set virtual common point moving positions corresponding to the center lines based on the virtual common point VP, at step S1006 in FIG. 10. The processing unit 120 is configured to move the virtual common point VP to the virtual common point moving positions to set sub-virtual common points corresponding to the ultrasound images, at step S1008 in FIG. 10.

In one embodiment, the processing unit 120 is configured to set a first virtual common point moving position for moving the virtual common point VP along the first center line CL_1. The processing unit 120 is further configured to move the virtual common point VP to the first virtual common point moving position to set a first sub-virtual common point SVP_1 corresponding to the first ultrasound image SF_1 as shown in FIG. 11. The processing unit 120 is also configured to set a second virtual common point moving position for moving the virtual common point VP along the second center line CL_2. The processing unit 120 is further configured to move the virtual common point VP to the second virtual common point moving position to set a second virtual common point SVP_2 corresponding to the second ultrasound image SF_2 as shown in FIG. 11. The processing unit 120 is additionally configured to set a third virtual common point moving position for moving the virtual common point VP along the third center line CL_3. The processing unit 120 is further configured to move the virtual common point VP to the third virtual common point moving position to set a third sub-virtual common point SVP_3 corresponding to the third ultrasound image SF_3 as shown in FIG. 11. The processing unit 120 is further configured to set a fourth virtual common point moving position for moving the virtual common point VP along the fourth center line CL_4. The processing unit 120 is configured to move the virtual common point VP to the fourth virtual common point moving position to set a fourth sub-virtual common point SVP_4 corresponding to the fourth ultrasound image SF_4 as shown in FIG. 11. The processing unit 120 is further configured to set a fifth virtual common point moving position for moving the virtual common point VP along the fifth center line CL_5. The processing unit 120 is also configured to move the virtual common point VP to the fifth virtual common point moving position to set a fifth sub-virtual common point SVP_5 corresponding to the fifth ultrasound image SF_5 as shown in FIG. 11.

The processing unit 120 is configured to set a plurality of scan-lines corresponding to each of the ultrasound images based on the virtual common point, the sub-virtual common points and the center lines, at step S1010 in FIG. 10. Thus, the ultrasound data acquisition unit 110 is configured to transmit the ultrasound signals to the living body along the scan-lines and receive the ultrasound echo signals from the living body to acquire the ultrasound data corresponding to each of the ultrasound images.

The methods of setting the plurality of scan-lines in the embodiment are similar to the methods of setting the plurality of scan-lines in the first embodiment. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure.

The processing unit 120 is configured to form the ultrasound images based on the ultrasound data provided from the ultrasound data acquisition unit 110, at step S1012 in FIG. 10.

[0068] In one example, the processing unit 120 is configured to form the first ultrasound image SF_1 based on the first ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 11. The processing unit 120 is further configured to form the second ultrasound image SF_2 based on the second ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 11. The processing unit 120 is also configured to form the third ultrasound image SF_3 based on the third ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 11. The processing unit 120 is further configured to form the fourth ultrasound image SF_4 based on the fourth ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 11. The processing unit 120 is further configured to form the fifth ultrasound image SF5 based on the fifth ultrasound data provided from the ultrasound data acquisition unit 110, as shown in FIG. 11.

[0069] The processing unit 120 is configured to perform spatial compounding upon the ultrasound images to form an ultrasound spatial compound image, at step S1014 in FIG. 10. The methods of performing the spatial compounding are well known in the art. Thus, they have not been described in detail so as not to unnecessarily obscure the present disclosure. For example, the processing unit 120 performs the spatial compounding by calculating a mean brightness value corresponding to each of the pixels of the ultrasound images.

Claims

1. An ultrasound system (100), comprising:

an ultrasound data acquisition unit (110) including an ultrasound probe (210) having a convex shape, configured to acquire ultrasound data by transmitting and receiving ultrasound signals; and

a processing unit (120) in communication with the ultrasound data acquisition unit (110), the processing unit (120) being configured to

set a virtual common point, at which a plurality of scan-lines intersect, in consideration of positions of a plurality of elements in the ultrasound probe (210) having the convex shape,

set a plurality of center lines corresponding to a plurality of ultrasound images where each of the plurality of ultrasound images includes a part of an image display area for displaying an ultrasound image and converging into the virtual common point, said plurality of center lines including a first center line and a second center line, set a first plurality of scan lines corresponding to the first center line,

move the virtual common point along the second center line to a sub-virtual common point, to set a second plurality of scan lines corresponding to the second center line and converging to the sub-virtual common point,

form a plurality of ultrasound images corresponding to the first plurality of scan lines and the second plurality of scan lines, and

perform spatial compounding upon the ultrasound images to form an ultrasound spatial compound image,

wherein the ultrasound data acquisition unit (110) is configured to acquire the ultrasound data based on the plurality of scan-lines,

wherein the number of the plurality of center lines is determined depending on the number of ultrasound images to be compounded, **characterised in that** the processing unit (120) is configured to: detect an element of the ultrasound probe (210), through which the second center line passes;

detect a center point of the detected element;

set a reference scan-line passing through the center point of the element on a basis of the sub-virtual common point corresponding to a reference ultrasound image;

set the second plurality of scan-lines based on the reference scan-line and the sub-virtual common point; and

rotate the second center line to a third center line to set a third plurality of scan-lines.

2. The ultrasound system (100) of Claim 1, wherein the reference scan-line is the first scan-line or the last scan-line for the reference ultrasound image.

3. The ultrasound system (100) of Claim 1, wherein the processing unit (120) is further configured to:

set a rotating angle for rotating ultrasound im-

ages corresponding to the second center line based on the sub-virtual common point;
rotate the ultrasound images corresponding to the second center line to the rotating angle based on the sub-virtual common point; and
reset the second plurality of scan-lines based on the rotating angle.

4. A method of providing an ultrasound spatial compound image, comprising:

a) setting a virtual common point, at which a plurality of scan-lines intersect, in consideration of positions of a plurality of elements in an ultrasound probe (210) having a convex shape, and setting a plurality of center lines corresponding to a plurality of ultrasound images where each of the plurality of ultrasound images includes a part of an image display area for displaying an ultrasound image and converging into the virtual common point, said plurality of center lines including a first center line and a second center line;
b) setting a first plurality of scan lines corresponding to the first center line;
c) moving the virtual common point along the second center line to a sub-virtual common point;
d) setting a second plurality of scan-lines corresponding to the second center line and converging to the sub-virtual common point;
e) acquiring ultrasound data by transmitting and receiving ultrasound signals based on the first and second plurality of scan-lines;
f) forming a plurality of ultrasound images corresponding to the first and second plurality of scan-lines based on the ultrasound data; and
g) performing spatial compounding upon the ultrasound images to form an ultrasound spatial compound image

wherein the number of the plurality of center lines is determined depending on the number of ultrasound images to be compounded, **characterised in that** d) comprises:

detecting an element of the ultrasound probe (210), through which the second center line passes;
detecting a center point of the detected element;
setting a reference scan-line passing through the center point of the element on a basis of the sub-virtual common point corresponding to a reference ultrasound image;
setting the second plurality of scan-lines based on the reference scan-line and sub-virtual common point; and
rotating the second center line to set a third plurality of scan-lines.

5. The method of Claim 4, wherein the reference scan-line is the first scan-line or the last scan-line for the reference ultrasound image.

Patentansprüche

1. Ultraschallsystem (100), welches Folgendes aufweist:

eine Ultraschalldatenerlangungseinheit (110), die eine Ultraschallsonde (210) mit einer konvexen Form aufweist, die dafür vorgesehen ist, Ultraschalldaten durch Übertragen und Empfangen von Ultraschallsignalen zu erlangen; und
eine Verarbeitungseinheit (120), die in Verbindung mit der Ultraschalldatenerlangungseinheit (110) steht, wobei die Verarbeitungseinheit (120) für Folgendes vorgesehen ist:

Festlegen eines virtuellen gemeinsamen Punkts, an dem sich eine Vielzahl von Scanlinien schneiden, unter Berücksichtigung von Positionen einer Vielzahl von Elementen in der Ultraschallsonde (210), die die konvexe Form aufweist,
Festlegen einer Vielzahl von Mittellinien, die mit einer Vielzahl von Ultraschallbildern korrespondieren, wobei jedes der Vielzahl von Ultraschallbildern einen Teil eines Bildanzeigebereichs zum Anzeigen eines Ultraschallbilds und Konvergieren in den virtuellen gemeinsamen Punkt beinhaltet, wobei die Vielzahl von Mittellinien eine erste Mittellinie und eine zweite Mittellinie aufweist,
Festlegen einer ersten Vielzahl von Scanlinien, die mit der ersten Mittellinie korrespondieren,
Bewegen des virtuellen gemeinsamen Punkts entlang der zweiten Mittellinie zu einem subvirtuellen gemeinsamen Punkt, um eine zweite Vielzahl von Scanlinien, die mit der zweiten Mittellinie korrespondieren, festzulegen und zu dem subvirtuellen gemeinsamen Punkt zu konvergieren,
Erzeugen einer Vielzahl von Ultraschallbildern, die mit der ersten Vielzahl von Scanlinien und der zweiten Vielzahl von Scanlinien korrespondieren, und
Durchführen eines räumlichen Zusammensetzens der Ultraschallbilder, um ein räumliches zusammengesetztes Ultraschallbild zu erzeugen,

wobei die Ultraschalldatenerlangungseinheit (110) dafür vorgesehen ist, die Ultraschalldaten

basierend auf der Vielzahl von Scanlinien zu erlangen,
wobei die Anzahl der Vielzahl von Mittellinien abhängig von der Anzahl der Ultraschallbilder, die zusammenzusetzen sind, ermittelt bzw. festgelegt wird,
dadurch gekennzeichnet, dass
die Verarbeitungseinheit (120) für Folgendes vorgesehen ist:

Detektieren eines Elements der Ultraschallsonde (210), durch welches die zweite Mittellinie verläuft;
Detektieren eines Mittelpunkts des detektierten Elements;
Festlegen einer Referenz-Scanlinie, welche durch den Mittelpunkt des Elements verläuft, auf einer Basis des subvirtuellen gemeinsamen Punkts entsprechend einem Referenzultraschallbild;
Festlegen der zweiten Vielzahl von Scanlinien basierend auf der Referenz-Scanlinie und dem subvirtuellen gemeinsamen Punkt; und
Rotieren der zweiten Mittellinie zu einer dritten Mittellinie, um eine dritte Vielzahl von Scanlinien festzulegen.

2. Ultraschallsystem (100) nach Anspruch 1, wobei die Referenz-Scanlinie die erste Scanlinie oder die letzte Scanlinie für das Referenzultraschallbild ist.

3. Ultraschallsystem (100) nach Anspruch 1, wobei die Verarbeitungseinheit (120) des Weiteren für Folgendes vorgesehen ist:

Festlegen eines Rotationswinkels zum Rotieren von Ultraschallbildern, die mit der zweiten Mittellinie korrespondieren, basierend auf dem subvirtuellen gemeinsamen Punkt;
Rotieren der Ultraschallbilder, die mit der zweiten Mittellinie korrespondieren, zu dem Rotationswinkel basierend auf dem subvirtuellen gemeinsamen Punkt; und
Zurücksetzen der zweiten Vielzahl von Scanlinien basierend auf dem Rotationswinkel.

4. Verfahren zum Zurverfügungstellen eines räumlichen Ultraschallverbundbilds, welches Folgendes aufweist:

a) Festlegen eines virtuellen gemeinsamen Punkts, an dem sich eine Vielzahl von Scanlinien schneiden, unter Berücksichtigung von Positionen einer Vielzahl von Elementen in einer Ultraschallsonde (210), die eine konvexe Form aufweist, und festlegen einer Vielzahl von Mittellinien, die mit einer Vielzahl von Ultraschallbildern korrespondieren, wobei jedes der Vielzahl von Ultraschallbildern einen Teil eines Bildanzeigebereichs zum Anzeigen eines Ultraschallbilds und Konvergieren in den virtuellen gemeinsamen Punkt beinhaltet, wobei die Vielzahl von Mittellinien eine erste Mittellinie und eine zweite Mittellinie aufweist;
b) Festlegen einer ersten Vielzahl von Scanlinien, die mit der ersten Mittellinie korrespondieren;
c) Bewegen des virtuellen gemeinsamen Punkts entlang der zweiten Mittellinie zu einem subvirtuellen gemeinsamen Punkt;
d) Festlegen einer zweiten Vielzahl von Scanlinien, die mit der zweiten Mittellinie korrespondieren, und Konvergieren zu dem subvirtuellen gemeinsamen Punkt;
e) Erlangen von Ultraschalldaten durch Übertragen und Empfangen von Ultraschallsignalen basierend auf den ersten und zweiten Vielzahlen von Scanlinien;
f) Erzeugen einer Vielzahl von Ultraschallbildern, die mit der ersten und der zweiten Vielzahl von Scanlinien korrespondieren, basierend auf den Ultraschalldaten; und
g) Durchführen eines räumlichen Zusammensetzens der Ultraschallbilder, um ein räumlich zusammengesetztes Ultraschallbild zu erzeugen,

wobei die Anzahl der Vielzahl von Mittellinien abhängig von der Anzahl der Ultraschallbilder, die zusammenzusetzen sind, ermittelt bzw. festgelegt wird,
dadurch gekennzeichnet, dass

d) folgendes aufweist:

- Detektieren eines Elements der Ultraschallsonde (210), durch welches die zweite Mittellinie verläuft;

Detektieren eines Mittelpunkts des detektierten Elementes;
Festlegen einer Referenz-Scanlinie, welche durch den Mittelpunkt des Elements verläuft, auf einer Basis des subvirtuellen gemeinsamen Punkts entsprechend einem Referenzultraschallbild;
Festlegen der zweiten Vielzahl von Scanlinien basierend auf der Referenz-Scanlinie und dem subvirtuellen gemeinsamen Punkt; und
Rotieren der zweiten Mittellinie, um eine dritte Vielzahl von Scanlinien festzulegen.

5. Verfahren nach Anspruch 4, wobei die die Referenz-Scanlinie die erste Scanlinie oder die letzte Scanlinie für das Referenzultraschallbild ist.

Revendications

1. Système ultrasonique (100) comportant :

une unité d'acquisition de données ultrasoniques (110) incluant une sonde ultrasonique (210) ayant une forme convexe, configurée pour acquérir des données ultrasoniques en transmettant et en recevant des signaux ultrasoniques ; et
une unité de traitement (120) en communication avec l'unité d'acquisition de données ultrasoniques (110), l'unité de traitement (120) étant configurée pour déterminer un point commun virtuel, auquel une pluralité de lignes de balayage se coupent, en considération de positions d'une pluralité d'éléments dans la sonde ultrasonique (210) ayant une forme convexe,
déterminer une pluralité de lignes centrales correspondant à une pluralité d'images ultrasoniques dont chaque pluralité d'images ultrasoniques comporte une partie d'une zone d'affichage d'image pour afficher une image ultrasonique et converger vers le point virtuel commun, ladite pluralité de lignes centrales incluant une première ligne centrale et une seconde ligne centrale,
définir une première pluralité de lignes de balayage correspondant à la première ligne centrale,
déplacer le point virtuel commun le long de la seconde ligne centrale vers un point commun sub-virtuel, pour déterminer une seconde pluralité de lignes de balayage correspondant à la seconde ligne centrale et converger vers le point commun sub-virtuel,
former une pluralité d'images ultrasoniques correspondant à la première pluralité de lignes de balayage et à la seconde pluralité de lignes de balayage, et
effectuer une composition spatiale avec les images ultrasoniques pour constituer une image spatiale ultrasonique composée,
dans lequel l'unité d'acquisition de données ultrasoniques (110) est configurée pour acquérir les données ultrasoniques basées sur la pluralité de lignes de balayage,
dans lequel le nombre de la pluralité de lignes centrales est déterminé en fonction du nombre d'images ultrasoniques devant être composées,
caractérisé en ce que l'unité de traitement (120) est configurée pour :

détecter un élément de la sonde ultrasonique (210) par lequel passe la seconde ligne centrale ;
détecter un point central de l'élément détecté ;
déterminer une ligne de balayage de référence passant à travers le point central de l'élément sur une base du point commun sub-virtuel correspondant à une image de référence ultrasonique ;
déterminer la seconde pluralité de lignes de balayage basées sur la ligne de balayage de référence et le point commun sub-virtuel, et
tourner la seconde ligne centrale vers une troisième ligne centrale pour déterminer une troisième pluralité de lignes de balayage.

2. Système ultrasonique (100) de la revendication 1, dans lequel la ligne de balayage de référence est la première ligne de balayage ou la dernière ligne de balayage pour l'image ultrasonique de référence.

3. Système ultrasonique (100) de la revendication 1, dans lequel l'unité de traitement (120) est en outre configurée pour :

déterminer un angle de rotation pour tourner des images ultrasoniques correspondant à la seconde ligne centrale basée sur le point commun sub-virtuel ;
tourner les images ultrasoniques correspondant à la seconde ligne centrale de l'angle de rotation basé sur le point commun sub-virtuel ; et
réinitialiser la seconde pluralité de lignes de balayage basées sur l'angle de rotation.

4. Procédé pour réaliser une image ultrasonique spatiale composée, comportant :

a) la détermination d'un point virtuel commun, auquel une pluralité de lignes de balayage se coupent, en considération de positions d'une pluralité d'éléments dans une sonde ultrasonique (210) ayant une forme convexe, et déterminant une pluralité de lignes centrales correspondant à une pluralité d'images ultrasoniques dont chaque pluralité d'images ultrasoniques inclut une partie d'une zone d'affichage d'une image pour afficher une image ultrasonique et converger vers le point commun virtuel, ladite pluralité de lignes centrales incluant une première ligne centrale et une seconde ligne centrale ;
b) la détermination d'une première pluralité de lignes de balayage correspondant à la première ligne centrale ;
c) le déplacement du point commun virtuel le long de la seconde ligne centrale vers un point commun sub-virtuel ;
d) la détermination d'une seconde pluralité de lignes de balayage correspondant à la seconde ligne centrale et la convergence vers le point commun sub-virtuel ;

e) l'acquisition de données ultrasoniques par transmission et réception de signaux ultrasoniques basés sur la première et la seconde pluralité de lignes de balayage ;
f) la formation d'une pluralité d'images ultrasoniques correspondant à la première et la seconde pluralité de lignes de balayage basées sur les données ultrasoniques, et
g) la réalisation d'une composition spatiale avec les images ultrasoniques pour constituer une image spatiale ultrasonique composée, dans laquelle le nombre de la pluralité de lignes centrales est déterminé en fonction du nombre d'images ultrasoniques devant être composées,

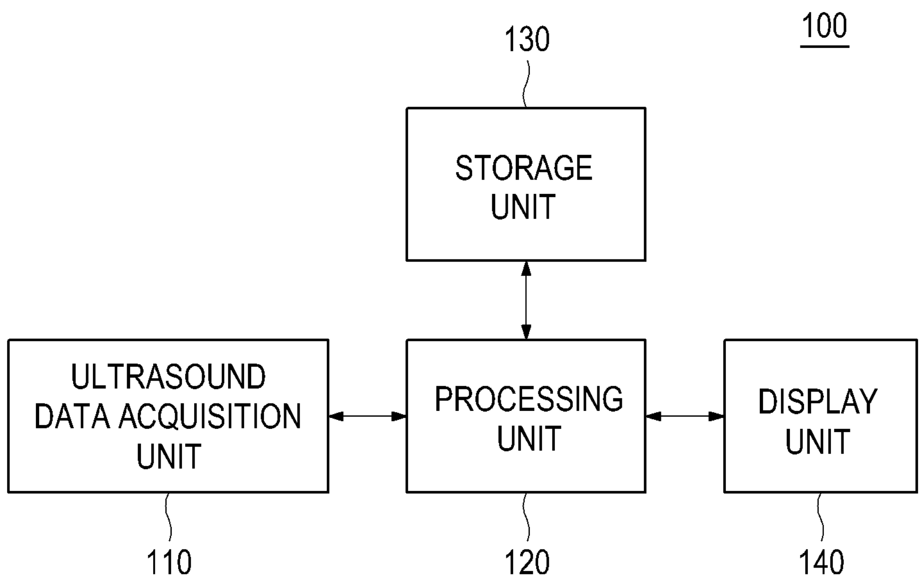
caractérisé en ce que,

d) comprend :

la détection d'un élément de la sonde ultrasonique (210), par lequel passe la seconde ligne centrale ;
la détection d'un point central de l'élément détecté ;
la détermination d'une ligne de balayage de référence passant par le point central de l'élément sur la base du point commun sub-virtuel correspondant à une image ultrasonique de référence ;
la détermination de la seconde pluralité de lignes de balayage basée sur la ligne de balayage de référence et le point commun sub-virtuel ; et
la rotation de la seconde ligne centrale pour déterminer une troisième pluralité de lignes de balayage.

5. Procédé selon la revendication 4, dans lequel la ligne de balayage de référence est la première ligne de balayage ou la dernière ligne de balayage pour l'image ultrasonique de référence.

FIG. 1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100
STORAGE UNIT
ULTRASOUND DATA ACQUISITION UNIT
PROCESSING UNIT
DISPLAY UNIT
110
120
140

FIG. 2

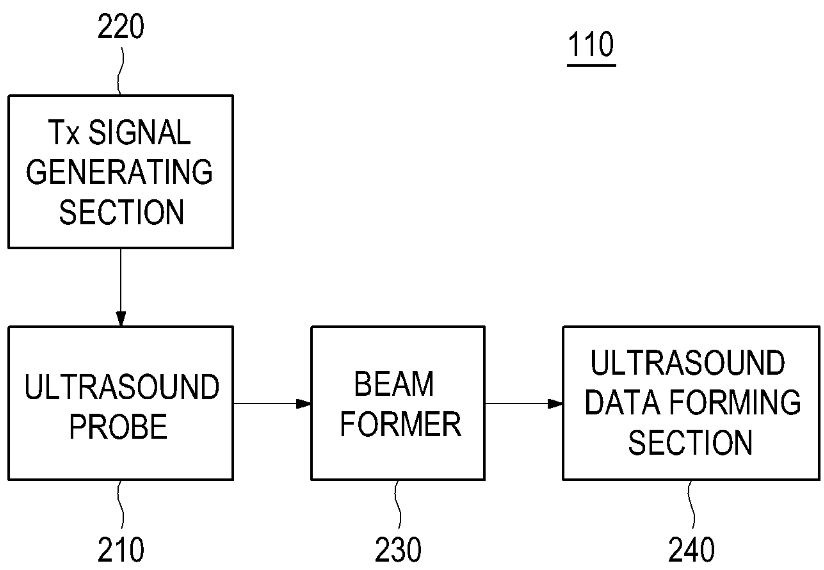

220
110
Tx SIGNAL GENERATING SECTION
ULTRASOUND PROBE
BEAM FORMER
ULTRASOUND DATA FORMING SECTION
210
230
240

FIG. 3

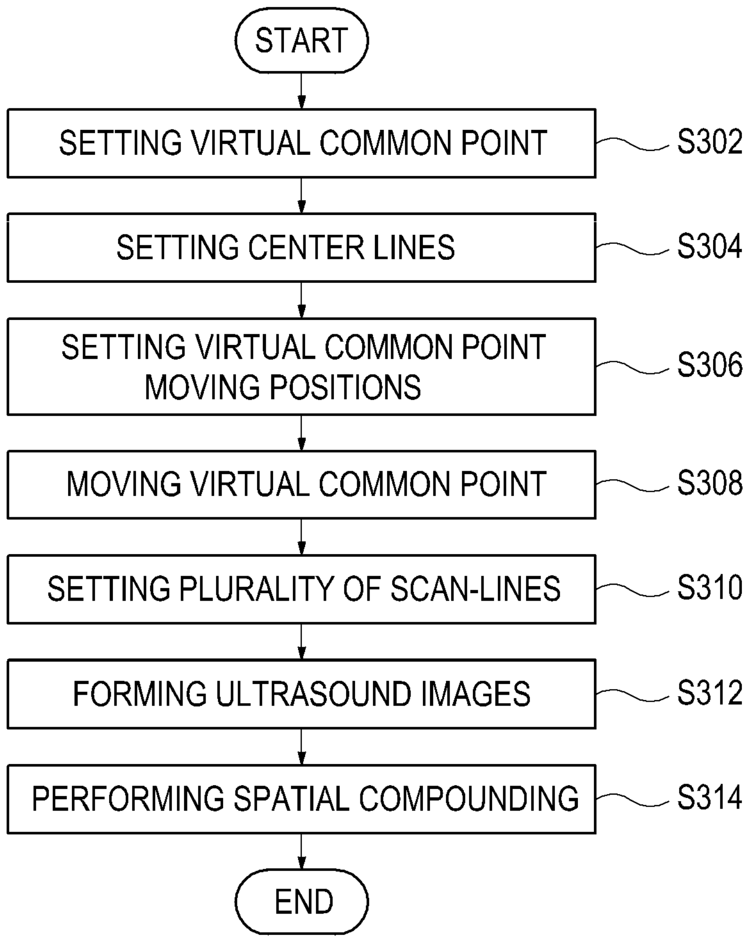

START
SETTING VIRTUAL COMMON POINT
S302
SETTING CENTER LINES
S304
SETTING VIRTUAL COMMON POINT MOVING POSITIONS
S306
MOVING VIRTUAL COMMON POINT
S308
SETTING PLURALITY OF SCAN-LINES
S310
FORMING ULTRASOUND IMAGES
S312
PERFORMING SPATIAL COMPOUNDING
S314
END

FIG. 4

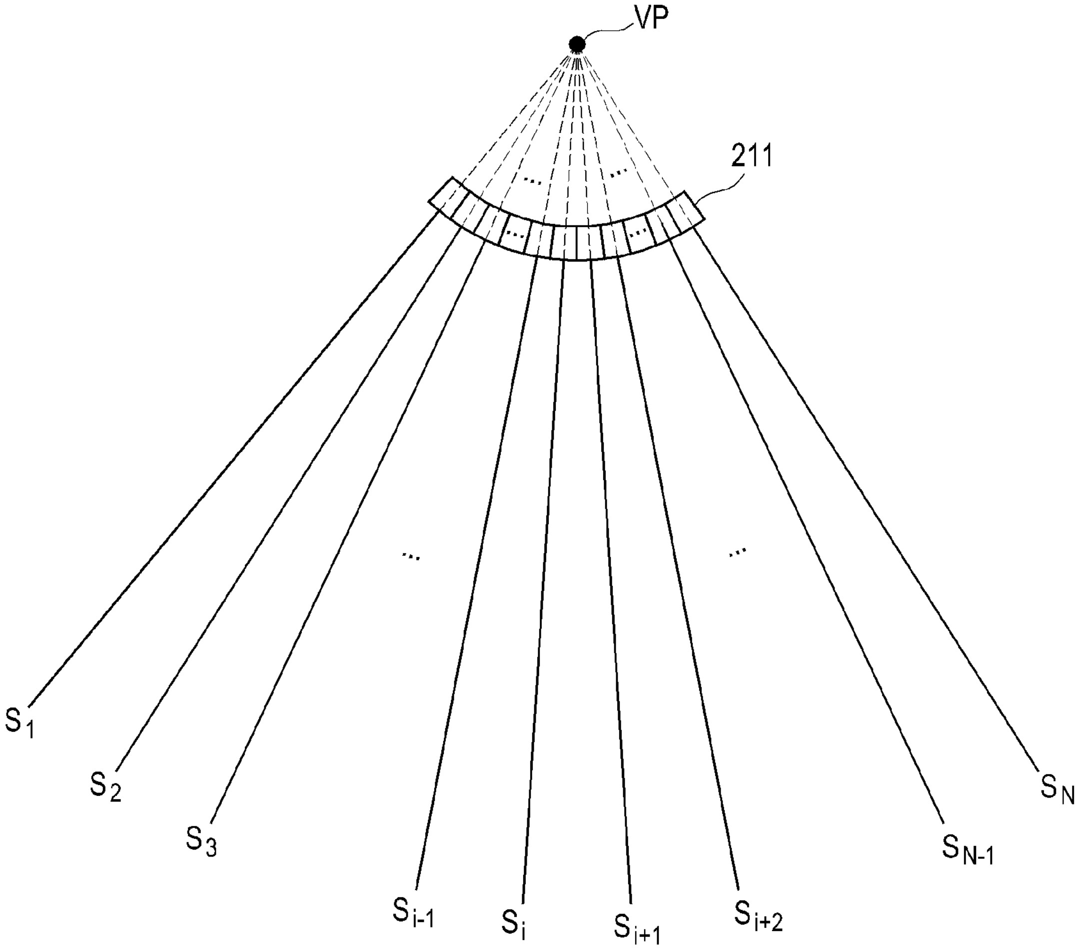


FIG. 5

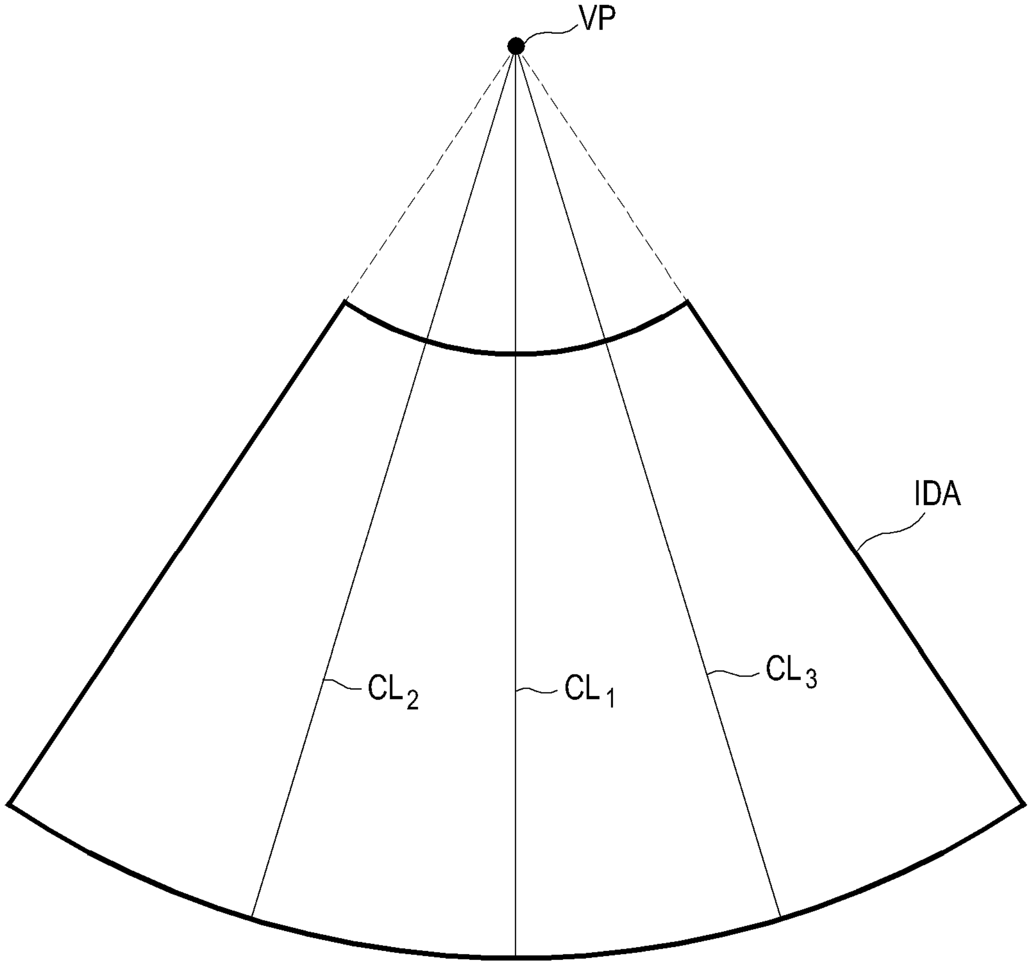


FIG. 6

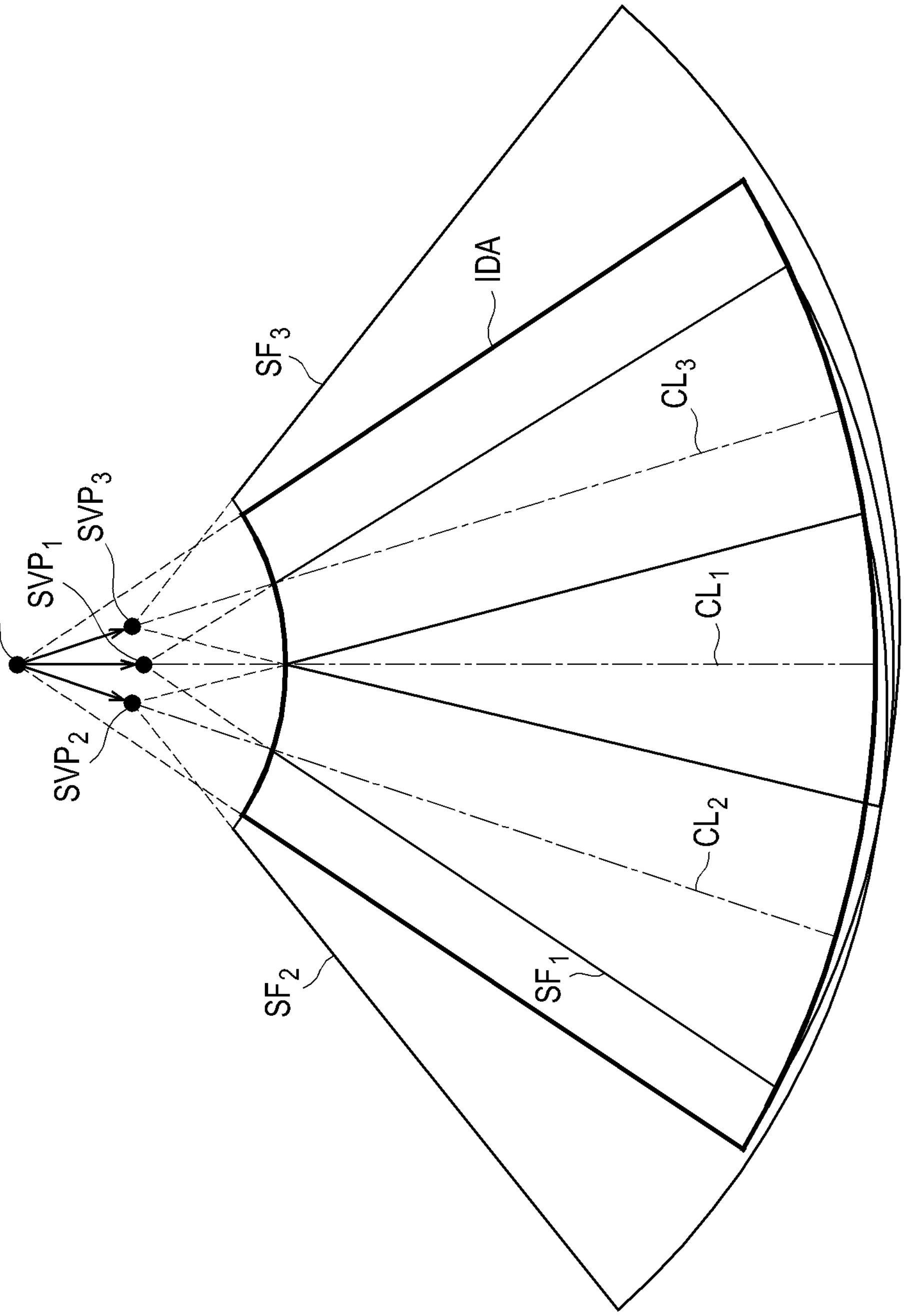
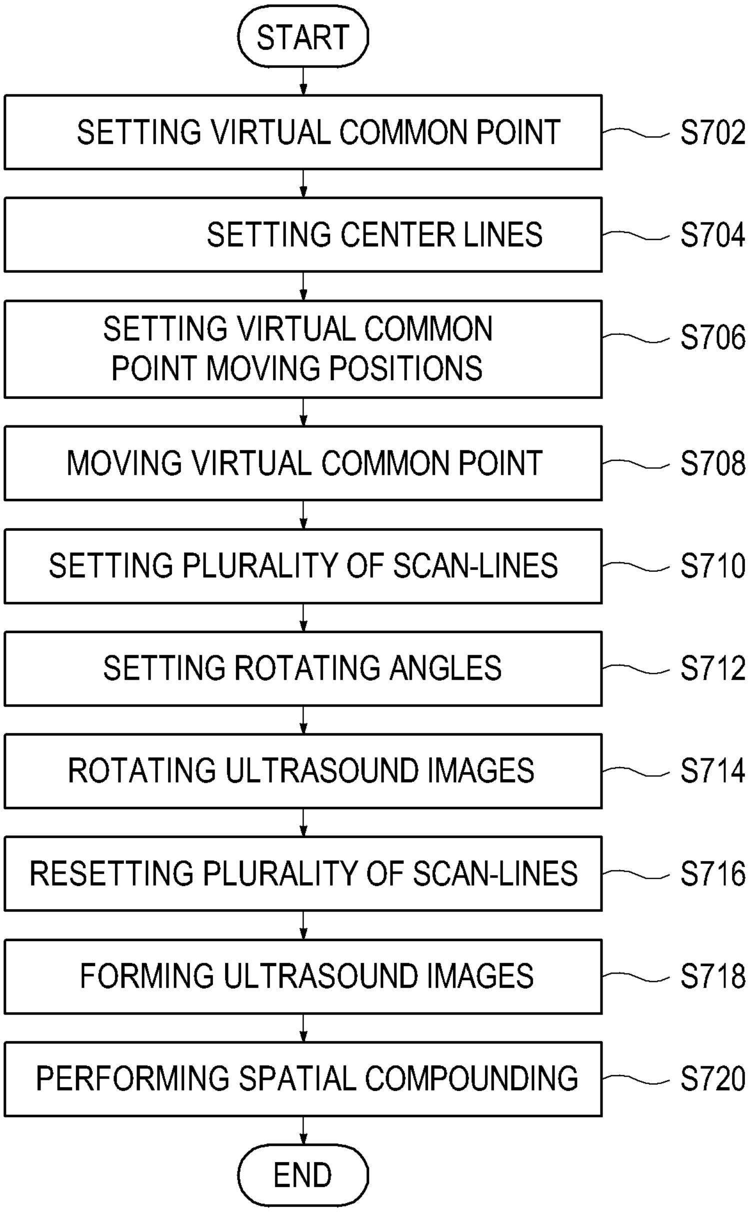


FIG. 7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S702
SETTING CENTER LINES
S704
SETTING VIRTUAL COMMON POINT MOVING POSITIONS
S706
MOVING VIRTUAL COMMON POINT
S708
SETTING PLURALITY OF SCAN-LINES
S710
SETTING ROTATING ANGLES
S712
ROTATING ULTRASOUND IMAGES
S714
RESETTING PLURALITY OF SCAN-LINES
S716
FORMING ULTRASOUND IMAGES
S718
PERFORMING SPATIAL COMPOUNDING
S720
END

FIG. 8

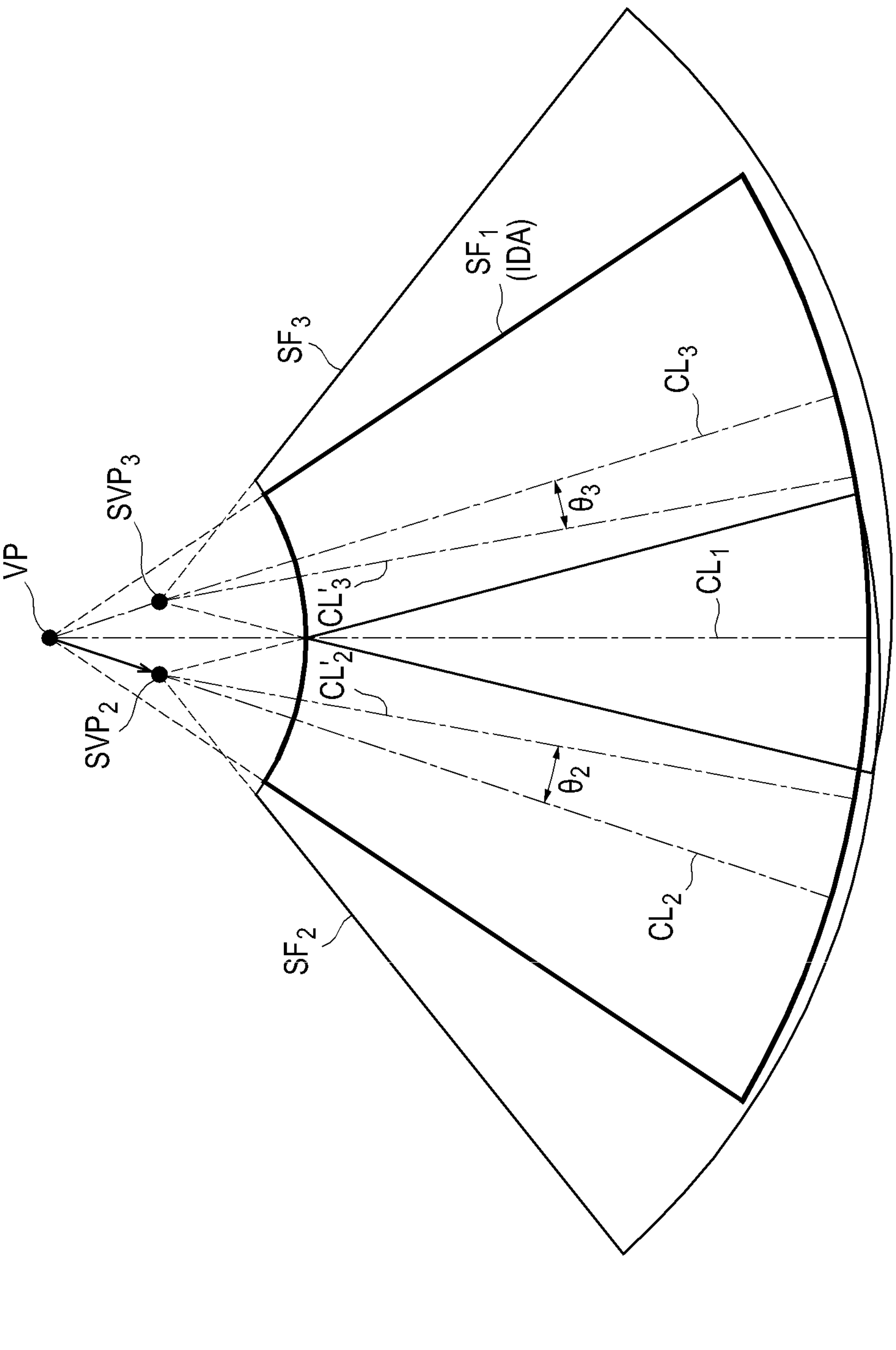


FIG. 9

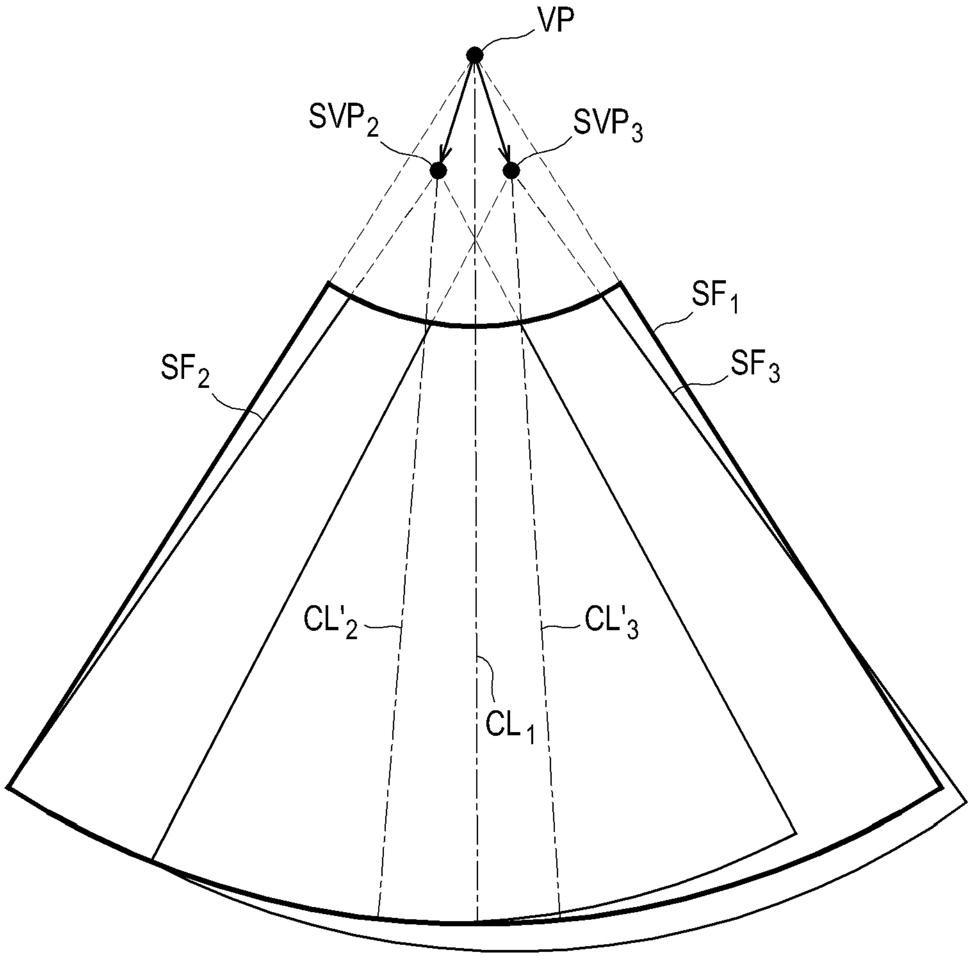


FIG. 10

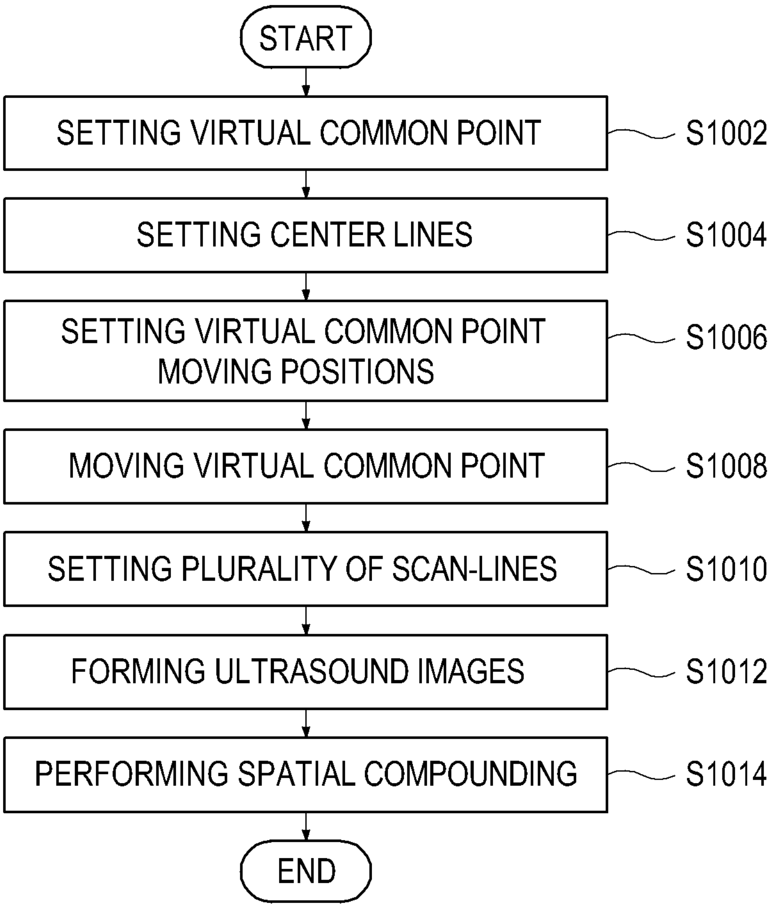
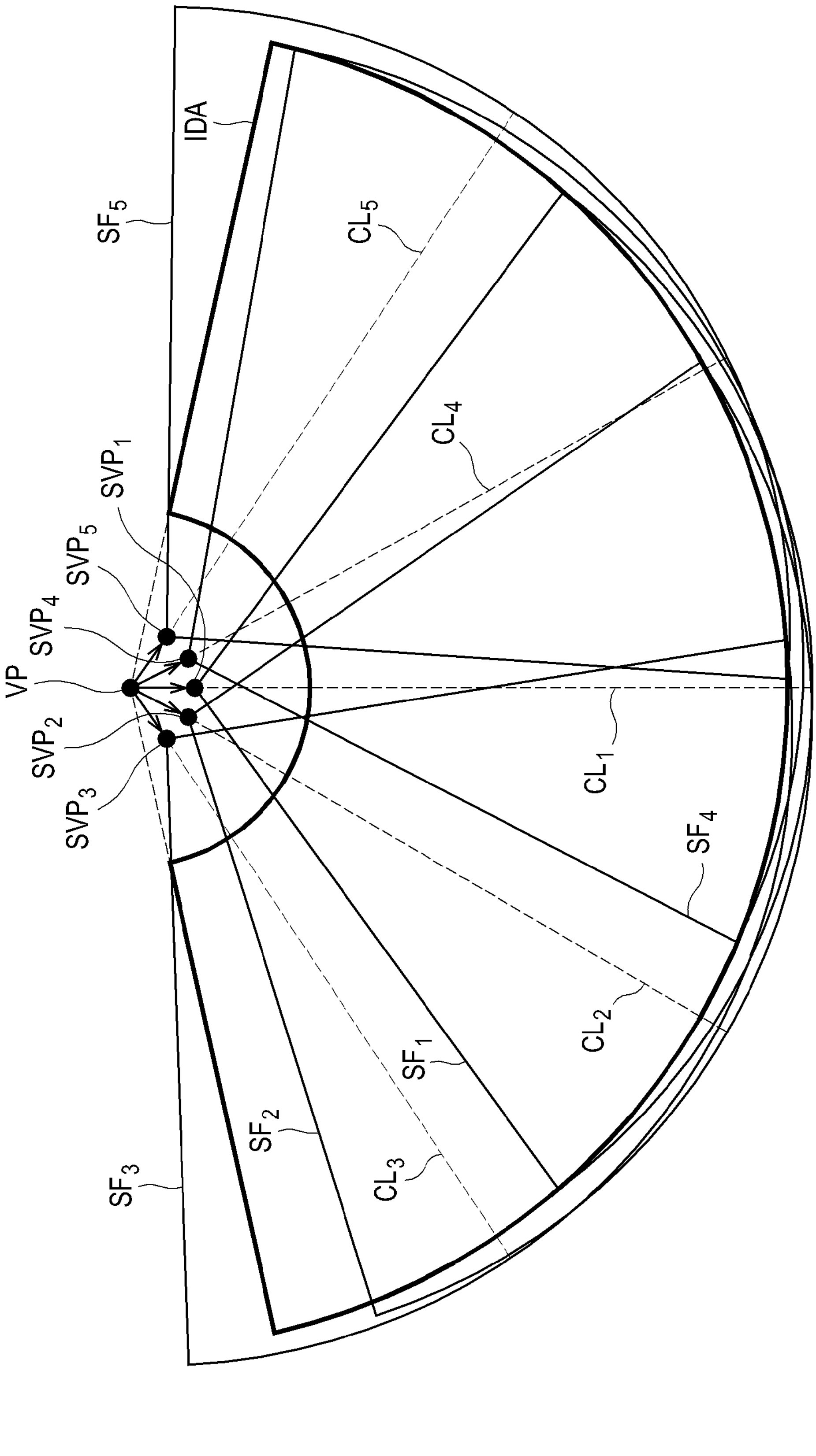

START
SETTING VIRTUAL COMMON POINT
S1002
SETTING CENTER LINES
S1004
SETTING VIRTUAL COMMON POINT MOVING POSITIONS
S1006
MOVING VIRTUAL COMMON POINT
S1008
SETTING PLURALITY OF SCAN-LINES
S1010
FORMING ULTRASOUND IMAGES
S1012
PERFORMING SPATIAL COMPOUNDING
S1014
END

FIG. 11



SF_5
IDA
CL_5
CL_4
SVP_1
SVP_5
SVP_4
VP
SVP_2
SVP_3
CL_1
SF_4
CL_2
SF_1
SF_2
CL_3
SF_3

REFERENCES CITED IN THE DESCRIPTION

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- EP 1903353 A1 **[0006]**
- EP 1906207 A1 **[0007]**
- US 6814701 B1 **[0008]**
- US 2009069681 A1 **[0009]**
- US 2004054284 A1 **[0010]**
- US 2004225218 A1 **[0011]**

专利名称(译)	在超声系统中基于超声图像的中心线提供超声空间复合图像		
公开(公告)号	[EP2444821B1](EP2444821B1)	公开(公告)日	2018-07-18
申请号	EP2011177864	申请日	2011-08-17
[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	LEE KWANG JU		
发明人	LEE, KWANG JU		
IPC分类号	G01S15/89 G01S7/52 A61B8/08		
CPC分类号	G01S15/8995 A61B8/5253 G01S7/52085 G01S15/8915		
代理机构(译)	SCHMID，WOLFGANG		
优先权	1020100101608 2010-10-19 KR		
其他公开文献	EP2444821A3 EP2444821A2		
外部链接	Espacenet		

摘要(译)

公开了用于提供超声空间复合图像的实施例。在一个实施例中，作为非限制性示例，超声系统包括：超声数据获取单元，被配置为通过发送和接收超声信号来获取超声数据;处理单元，其与超声数据获取单元通信的处理单元，被配置为基于与预定扫描线对应的虚拟公共点设置多个中心线，沿着每个中心线移动虚拟公共点。设置多条扫描线，基于超声数据形成与中心线对应的多个超声图像，并对超声图像进行空间复合，以形成超声空间复合图像，其中，超声数据采集单元被配置为基于多条扫描线获取超声数据。

FIG. 1

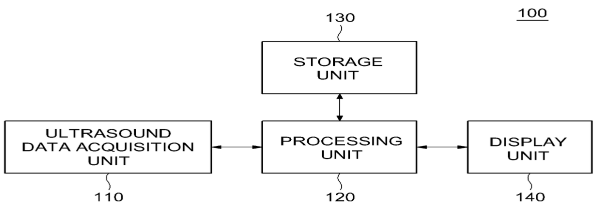

FIG. 2