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(54) AN ULTRASOUND IMAGING SYSTEM AND AN ULTRASOUND IMAGING METHOD

ULTRASCHALLBILDGEBUNGSSYSTEM UND ULTRASCHALLBILDGEBUNGSVERFAHREN

SYSTÈME ET PROCÉDÉ D'IMAGERIE PAR ULTRASONS

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to ultrasound imaging, more particularly to an ultrasound imaging system and an ultrasound imaging method for improving the imaging quality of the desired imaging plane in the volume of interest of a subject.

BACKGROUND OF THE INVENTION

[0002] A conventional one-dimensional (1D) ultrasound probe comprises a line of transducer elements from which ultrasonic signals may be emitted. Furthermore, an image plane underneath the transducer elements may be observed by detecting echoes of reflected ultrasonic signals coming from inhomogeneities of the observed region. By correctly positioning and moving the ultrasound transducer, a volume of interest of the subject comprising for example a lesion may be observed.

[0003] In ultrasound imaging of a volume of interest, a clinical challenge for doctors - especially junior doctors - is how to find an imaging plane for the volume of interest which is suitable or desirable for a certain clinical purpose. Supporting doctors to find the desired imaging plane is very valuable and highly required for clinical doctors. From the point of view of computerized techniques, the 2D image data acquired by the one-dimensional ultrasound probe may not provide sufficient information to do this, since the human body is a 3D object. Currently, the research work done for this goal is mainly based on 3D (acquired by using a matrix transducer comprising a two-dimensional array of transducer elements) or higher-dimensional data and once the high-dimensional data is obtained, the desired imaging plane with the object that doctors want to see may be determined and the corresponding 2D image of the desired imaging plane is displayed.

[0004] As regards the two-dimensional matrix ultrasound transducer, such a transducer may comprise an array of ultrasound transducer elements arranged in columns and rows. The transducer array face may still be rectangular as in the case of a one-dimensional ultrasound transducer, but the array of transducer elements is arranged in a two-dimensional matrix. This additional complexity may allow ultrasound beams to be steered and focused through a three-dimensional space rather than in only a plane. As is known to those skilled in the art, the two-dimensional matrix ultrasound transducer may acquire the three-dimensional volume data of the volume of interest from ultrasound echo data of a plurality of scanning planes in the volume of interest. The plurality of scanning planes may be determined by the setting parameters for the transducer elements, for example, which lines or rows are to be enabled, and the beamforming parameters for the enabled elements.

[0005] Once the three-dimensional volume data of the volume of interest is acquired, any desired image plane can be reconstructed via computer processing algorithms, for example, by interpolation of the ultrasound echo data of the plurality of scanning planes.

[0006] Nevertheless, although it may be easier for doctors to find the desired imaging plane for the volume of interest with a two-dimensional matrix ultrasound transducer, the quality of the reconstructed and displayed 2D image of the desired imaging plane may be unsatisfactory.

[0007] Specifically, current automated means to reconstruct the 2D image of the desired imaging plane have some disadvantages, for example fixed enablement of the transmit elements of the matrix transducer regardless of the desirable imaging plane, etc. In other words, the image of the determined desired imaging plane may not be constructed in the transmit direction of the ultrasound signal. Since the ultrasound signal will have a signal focusing process and the corresponding interpolation process, if the image of the desired imaging plane is not generated in the transmit direction (i.e., not generated by the ultrasound echo data of the desired imaging plane itself) but reconstructed by interpolation of the ultrasound echo data of the plurality of scanning planes in the volume of interest, the quality of the constructed 2D image may be highly affected and sometimes clinical diagnosis cannot be performed for some applications where a high data quality is required.

[0008] Patent application publication US 2012/157845 A1 describes an ultrasound imaging system and method that include: acquiring first ultrasound data, the first ultrasound data comprising data of a first plane through a structure of interest; tracking the motion of a landmark based on the first ultrasound data; and acquiring second ultrasound data, the second ultrasound data including data of a second plane through the structure of interest, the second plane being distinct from the first plane, where the position of the second plane is adjusted to track the motion of the landmark. The ultrasound imaging system and method also includes generating an image based on the second ultrasound data.

[0009] Document US 2010/260398 A1 relates to a systems and a method which provide volume imaging by implementing survey and target imaging modes. The survey imaging mode is implemented to provide a volume image of a relatively large survey area. A target of interest is preferably identified within the survey area for use in the target imaging mode. The target imaging mode is implemented to provide a volume image of a relatively small target area corresponding to the identified target of interest. The target imaging mode preferably adapts the beamforming, volume field of view and/or other signal and image processing algorithms to the target area. In operation, the target imaging mode provides a volume image of a target area with improved volume rate and image quality.

SUMMARY OF THE INVENTION

[0010] Therefore, there is a need for a novel ultrasound imaging system and method, which is capable of improving the imaging quality of the desired imaging plane.

[0011] In accordance with an aspect of the present invention, there is proposed an ultrasound imaging system, comprising:

an ultrasound probe with a two-dimensional array of transducer elements, for transmitting ultrasound signals and acquiring three-dimensional volume data of a volume of interest of a subject when the probe is positioned at a first position on the subject and tilted at a first angle relative to the volume of interest and the transducer elements of the probe have a first set of setting parameters, wherein the three-dimensional volume data of the volume of interest comprises ultrasound echo data of a plurality of scanning planes defined by the first set of setting parameters;
a processing unit for determining a desired imaging plane for the volume of interest in accordance with the three-dimensional volume data and for determining a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe, wherein the processing unit is further configured to derive - if the result is YES -the second set of setting parameters, and to derive - if the result is NO -a second position, a second angle and a third set of setting parameters such that when the probe is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane;
a transducer controller for adjusting the transducer elements in accordance with the derived second set of setting parameters if the result is Yes, and adjusting the transducer elements in accordance with the derived third set of setting parameters if the result is NO; and
a display for, if the result is NO, outputting an instruction to guide a user of the ultrasound imaging system to move the probe so as to be positioned at the second position and tilted at the second angle.

[0012] In this way, it is possible to directly scan the desired imaging plane by exploiting the capability of a 2D matrix ultrasound transducer and/or the flexibility of the position/orientation of the ultrasound probe. In some cases, the setting parameters of the transducer elements can be adjusted so that the ultrasound signal transmitted from the transducer elements is able to derive ultrasound echo data of the desired imaging plane without moving the probe. In other cases where the desired imaging plane cannot be directly scanned without changing the position/orientation of the ultrasound probe, the adjustment of the position/orientation of the ultrasound probe is possible by means of user interaction, namely outputting the instruction for guiding the user to move the probe so as to enable direct scanning of the desired imaging plane.

[0013] In this way, the image of the desired imaging plane is not reconstructed by interpolation of the ultrasound echo data of the plurality of scanning planes (which are determined by the setting parameters of the transducer elements), but the image is reconstructed from the ultrasound echo data of the desired imaging plane itself. In other words, the desired imaging plane is directly scanned. Thus, the image quality of the desired imaging plane is improved and may help doctors conduct a more accurate diagnosis.

[0014] In an embodiment of the present invention, the setting parameters of the transducer elements comprise which transducer elements are to be enabled and the beam-forming parameters for the enabled transducer elements.

[0015] As can be understood by those skilled in the art, the beam-forming parameters of the transducer elements may comprise, for example, the phase of the ultrasound signals transmitted by each of the enabled transducer elements and/or the beam-forming vectors adopted in the beam-forming element on the receiving side to synthesize the echo data of the ultrasound signals transmitted by the enabled transducer elements.

[0016] In an embodiment of the present invention, the elements of the transducer that should be enabled are determined first, and then the beam-forming parameters for the enabled elements are determined.

[0017] By first determining the corresponding elements of the transducer that should be enabled, it is possible to preliminarily constrain the set of planes that can be imaged in the volume of interest. Meanwhile, by not enabling all the elements the processing cost is reduced. Furthermore, the corresponding detailed direction of the transmitting signal is then determined by adjusting beam-forming parameters for the enabled elements. In this way, the transmitting signal from the enabled elements uniquely corresponds to the desired imaging plane.

[0018] In an embodiment of the present invention, the processing unit is configured to automatically determine the desired imaging plane for the volume of interest in accordance with the three-dimensional volume data, a clinical objective and a predetermined model.

[0019] By gaining prior-knowledge of the planes that doctors want to see, it is possible to have different options available if a predetermined model has been set for different clinical objectives. The plane detection methods could be different Hough transforms, segmentation-based methods or graphical models of different objects, etc. It should be noted that automatic determination of the desired imaging plane is realized in real-time here, which could provide more information for the whole of the process and for the following scanning plan as compared with conventional approaches.

[0020] In another embodiment of the present invention, the ultrasound imaging system may further comprise a user interface for receiving the user's input. In this case, the display may be further configured to display a plurality of images reconstructed from the three-dimensional volume data, and the processing unit may be further configured to determine the desired imaging plane for the volume of interest in accordance with the user's manual selection based on the plurality of images reconstructed from the three-dimensional volume data.

[0021] If the automatically determined imaging plane is not good enough or the automatic option is not available, doctors need to find the plane by themselves. Within the three-dimensional volume data, doctors manually move the plane and the plane position should be displayed in the current total 3D data. Since this should be performed in real-time during the scanning process, the interpretation of the displayed 2D image should not be more complicated than the conventional scanning operation. Meanwhile spatial information is provided, which makes it more convenient for doctors to interpret the image.

[0022] In accordance with another aspect of the present invention, there is proposed an ultrasound imaging method, comprising:

transmitting ultrasound signals and acquiring three-dimensional volume data of a volume of interest of a subject with an ultrasound probe having a two-dimensional array of transducer elements, wherein the probe is positioned at a first position on the subject and tilted at a first angle relative to the volume of interest and the transducer elements of the probe have a first set of setting parameters, and wherein the three-dimensional volume data of the volume of interest comprises ultrasound echo data of a plurality of scanning planes defined by the first set of setting parameters;

determining a desired imaging plane for the volume of interest in accordance with the three-dimensional volume data;

determining a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe;

deriving - if the result is YES: - the second set of setting parameters, and - if the result is NO: - deriving a second position, a second angle and a third set of setting parameters such that when the probe is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane; and

adjusting the transducer elements in accordance with the derived second set of setting parameters if the result is Yes, and outputting an instruction to guide a user of the ultrasound imaging system to move the probe so as to be positioned at the second positin and tilted at the second angle and adjusting the transducer elements in accordance with the derived third set of setting parameters if the result is NO.

[0023] As mentioned above, the ultrasound imaging method according to the present invention may improve the image quality of the desired imaging plane and may help doctors conduct a more accurate diagnosis since the image of the desired imaging plane is not reconstructed by processing the imaging data of one or more imaging planes different from the desired imaging plane but by directly processing the imaging data of the desired imaging plane.

[0024] Various aspects and features of the disclosure are described in further detail below. These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

DESCRIPTION OF THE DRAWINGS

[0025] The present invention will be described and explained hereinafter in more detail in combination with embodiments and with reference to the drawings, wherein:

Fig. 1 is a block diagram of an ultrasound imaging system 10 according to the present invention;

Fig. 2 is a block diagram of an ultrasound imaging method 20 according to the present invention;

Fig. 3a illustrates a condition where the desired imaging plane is intersected with the two-dimensional array of transducer elements, and Fig. 3b illustrates a condition where the desired imaging plane is not intersected with the two-dimensional array of transducer elements; and

Fig. 4a and Fig. 4b illustrate, in the case of Fig. 3b, how the display of the ultrasound imaging system 10 outputs an instruction to guide a user of the ultrasound imaging system to move the probe according to an embodiment of the present invention.

[0026] The same reference signs in the figures indicate similar or corresponding features and/or functionalities.

DETAILED DESCRIPTION

[0027] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn to scale for illustrative purposes.

[0028] Fig. 1 is a block diagram of an ultrasound imaging system 10 according to the present invention.

[0029] In the following, details of the ultrasound imaging system 10 will be described in conjunction with Fig. 2, which is a block diagram of the ultrasound imaging method 20 according to the present invention.

[0030] As can be seen from Fig. 1, the ultrasound imaging system 10 of the present invention comprises an ultrasound probe 11. According to the present invention, a two-dimensional array of transducer elements 110 is utilized in the probe 11, for transmitting ultrasound signals and acquiring three-dimensional volume data of a volume of interest of a subject (step 21 in Fig. 2). For example, the subject may be a patient and the volume of interest of the subject may be an organ of the patient.

[0031] In the following, the position at which the probe 11 is positioned on the subject when the three-dimensional volume data is acquired is referred to as the first position and the angle at which the probe is tilted relative to the volume of interest is referred to as the first angle.

[0032] Furthermore, as can be easily understood by those skilled in the art, a two-dimensional matrix ultrasound transducer may comprise an array of ultrasound transducer elements 110 arranged in columns and rows. The transducer array face may still be rectangular as in the case of a one-dimensional ultrasound transducer, but the array of transducer elements is arranged in a two-dimensional matrix. At the time of acquiring the three-dimensional volume data, a first set of setting parameters is predetermined for the transducer elements 110 of the probe 11. In other words, the first set of setting parameters determines which transducer elements are to be enabled as well as the beam-forming parameters for the enabled transducer elements. Therefore, the first set of setting parameters determines that a plurality of scanning planes of the two-dimensional matrix ultrasound transducer are arranged in columns or in rows, or even in diagonal directions. Accordingly, the acquired three-dimensional volume data of the volume of interest comprises ultrasound echo data of the plurality of scanning planes defined by the first set of setting parameters.

[0033] As can be seen from Fig. 1, the ultrasound imaging system 10 according to an embodiment of the present invention further comprises a processing unit 12 for determining a desired imaging plane 1 for the volume of interest in accordance with the three-dimensional volume data (step 21 in Fig. 2).

[0034] In an embodiment of the present invention, the processing unit 12 may be configured to automatically determine the desired imaging plane 1 for the volume of interest in accordance with the acquired three-dimensional volume data, a clinical objective and a predetermined model.

[0035] By gaining prior-knowledge of the planes that doctors want to see, different options can be made available if a predetermined model has been set for different clinical objectives. The plane detection methods could be different Hough transforms, segmentation-based methods or graphical models of different objects, etc. It should be noted that the automatic determination of the desired imaging plane is realized in real-time here, which could provide more information for the whole of the process and for a following scanning plan as compared with conventional approaches.

[0036] In another embodiment of the present invention, the ultrasound imaging system 10 may further comprise a user interface for receiving the user's input. In this case, the display may be further configured to display a plurality of images reconstructed from the three-dimensional volume data, and the processing unit 12 may be further configured to determine the desired imaging plane 1 for the volume of interest in accordance with the user's manual selection based on the plurality of images reconstructed from the three-dimensional volume data.

[0037] If the automatically determined imaging plane is not good enough or the automatic option is not available, the ultrasound system can be further configured to allow doctors to find the plane by themselves. Within the three-dimensional volume data, doctors can be provided with means to manually move the plane, and the plane position should be displayed in the current total 3D data. Since this should be performed in real-time during the scanning process, the interpretation of the displayed2 D image should not be more complicated than the conventional scanning operation. Meanwhile the spatial information is provided, which makes it more convenient for doctors to interpret the image.

[0038] As can be easily understood by those skilled in the art, the desired imaging plane 1 for the volume of interest is determined by considering the particular anatomical structure of the volume of interest and the particular target in the volume of interest, for example a potential lesion, and therefore is usually not one of the scanning planes. However, only the image of the scanning plane is generated from the transmitting signal in the transmit direction. If the desired imaging plane 1 is not one of the scanning planes, the image thereof is not reconstructed in the transmit direction of the ultrasound signal, i.e., not generated by the ultrasound echo data of the desired imaging plane itself, but reconstructed by interpolation of the ultrasound echo data of the plurality of scanning planes in the volume of interest, but the quality of the reconstructed 2D image may be highly adversely affected and sometimes clinical diagnosis cannot be performed for applications where high data quality is required.

[0039] In view of the above, the present invention exploits the capability of a 2D matrix ultrasound transducer, in which the enabled transducer elements and the beam-forming parameters for the enabled elements may be adjusted so that the ultrasound signal transmitted from the enabled transducer elements is able to derive ultrasound echo data of the desired imaging plane without moving the probe or after moving the probe to another position and tilted at another angle relative to the volume of interest.

[0040] Accordingly, the processing unit 12 of the present invention is further used to determine a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe 11 (step 23 in Fig. 2).

[0041] If the result is YES, the processing unit 12 is further configured to derive the second set of setting parameters (step 24 in Fig. 2). In this case, a transducer controller 13 comprised in the ultrasound imaging system 10 then adjusts the transducer elements 110 in accordance with the derived second set of setting parameters (step 25 in Fig. 2).

[0042] However, if the result is NO, i.e., if the probe 11 has to be moved (i.e., either one of the first position and the first angle, or even both of the first position and the first angle have to be changed), the processing unit 12 is further configured to derive a second position and a second angle for the probe 11 and derive a third set of setting parameters for the transducer elements 110 such that when the probe 11 is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane (step 26 in Fig. 2). In this case, the transducer controller 13 then adjusts the transducer elements 110 in accordance with the derived third set of setting parameters (step 27 in Fig. 2).

[0043] In an embodiment of the present invention, the processing unit 12 performs steps 23, 24 and 26 based on the spatial positional relationship between the first position and the first angle of the probe and the desired imaging plane 1 and based on the layout of the transducer elements 110.

[0044] The ultrasound imaging system 10 according to an embodiment of the present invention further comprises a display 14. If the result is NO, i.e., if the probe 11 has to be moved, the display 14 is used to output an instruction to guide a user of the ultrasound imaging system 10 to move the probe 11 so as to be positioned at the second position and tilted at the second angle. The schematic view of how to guide the user to move the probe 11 is shown in Fig. 4a and Fig. 4b, and will be explained hereinafter.

[0045] In an embodiment of the present invention, the display 14 is further configured to display an image of the desired imaging plane 1, which is reconstructed from the ultrasound echo data of the desired imaging plane 1.

[0046] In this way, the image of the desired imaging plane 1 is not reconstructed by interpolation of the ultrasound echo data of the plurality of scanning planes (which correspond to the ultrasound signals transmitted from the initial enabled elements and initial beam-forming parameters), but reconstructed from the ultrasound echo data of the desired imaging plane itself. Thus, the image quality of the desired imaging plane 1 is improved and may help doctors conduct a more accurate diagnosis.

[0047] The details of step 23, i.e., the determination of whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe 11 is further elaborated hereinafter in conjunction with Figs. 3a and 3b, which illustrate, respectively, a condition where the desired imaging plane 1 is intersected with the two-dimensional array of transducer elements 110, and a condition where the desired imaging plane 1 is not intersected with the two-dimensional array of transducer elements 110.

[0048] As can be understood from Fig. 3a, in the case that the desired imaging plane 1 is intersected with the two-dimensional array of transducer elements 110, it is determined that the result is YES, i.e., there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe 11.

[0049] Accordingly, the transducer elements on the intersection line 1a would be enabled and the transducer elements adjacent to the intersection line 1a would usually be enabled. This may preliminarily constrain the set of planes that can be imaged in the volume of interest.

[0050] Furthermore, the corresponding detailed direction of the transmitting signal is determined by adjusting beam-forming parameters for the enabled elements. In this way, the transmitting signal from the enabled elements uniquely corresponds to the desired imaging plane 1.

[0051] As can be understood from Fig. 3b, in the case that the desired imaging plane 1 is not intersected with the two-dimensional array of transducer elements 110, it is determined that the result is NO, i.e., there is not a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe 11. In other words, according to the limited scale of the two-dimensional array of transducer elements 110, the desired imaging plane 1, which is not intersected with the two-dimensional array of transducer elements 110, cannot be imaged with a real transmitting signal of the elements without moving the probe to another position different from the first position.

[0052] As mentioned above, if the result is NO, i.e., if the probe 11 has to be moved, the processing unit 12 is further configured to derive a second position and a second angle for the probe 11 and derive a third set of setting parameters for the transducer elements 110 such that when the probe 11 is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane (step 26 in Fig. 2).

[0053] As can be easily understood by those skilled in the art, usually the second position and the second angle are both different from the first position and the first angle. However, in some cases, the second angle may be the same as the first angle.

[0054] Fig. 4a and Fig. 4b illustrate, in the case of Fig. 3b, how the display 14 of the ultrasound imaging system outputs an instruction to guide a user of the ultrasound imaging system to move the probe according to an embodiment of the present invention.

[0055] As mentioned above, in the case of Fig. 3b, the desired imaging plane 1 is not intersected with the two-dimensional array of transducer elements 110. As shown in Figs. 4a and 4b, according to the layout of the transducer elements 110, a middle reference plane 2, which is underneath the centerline of the array of transducer elements 110, could be determined. Furthermore, according to the spatial positional relationship between the first position and the first angle of the probe 11 and the desired imaging plane 1, the second position, the second angle and the third set of setting parameters such that when the probe 11 is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements 110 having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane 1.

[0056] For example, according to the spatial positional relationship between the middle reference plane 2 and the plane 3 in a 3D space containing the desired imaging plane 1, the processing unit 12 is able to calculate the second position that the probe 11 should be moved to. Further, according to the spatial positional relationship between the centerline of the array of transducer elements 110 and the intersection line 1b of the middle reference plane 2 with the desired imaging plane 1, the processing unit 12 is able to calculate the second angle at which the probe 11 should be tilted relative to the volume of interest. After that, the processing unit 12 may derive that, at the second position and the second angle, the transducer elements on the centerline of the array (and some elements adjacent to the centerline) should be enabled and the beam-forming parameters for the enabled transducer elements could be determined accordingly, so that the desired imaging plane 1 could be directly obtained by the transmitting signal from the enabled elements.

[0057] As can be understood by those skilled in the art, the above-mentioned middle reference plane 2 is only used as an embodiment; other reference planes may also be used and the second position, the second angle and the third set of setting parameters could be similarly derived according to the selection of the reference plane.

[0058] If the second position and the second angle have been derived, the display 14 of the ultrasound imaging system 10 then outputs an instruction to guide a user of the ultrasound imaging system 10 to move the probe 11, for example the moving direction indicated by I_1 in Fig. 4b to guide the user to move the probe 11 to the second position and the rotation direction indicated by I_2 in Fig. 4b to guide the user to achieve the second angle of the probe 11. The instruction can be output in a format of text, graphics, or a combination thereof. In some embodiments, the display 14 is capable of outputting audio, and the instruction can be output in an audio format.

[0059] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention and that those skilled in the art would be able to design alternative embodiments within the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps not listed in a claim or in the description. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. In the system claims enumerating several units, several of these units can be embodied by one and the same item of software and/or hardware. The usage of the words first, second and third, etcetera, does not indicate any ordering. These words are to be interpreted as names.

Claims

1. An ultrasound imaging system (10), comprising:

an ultrasound probe (11) with a two-dimensional array of transducer elements (110), for transmitting ultrasound signals and acquiring three-dimensional volume data of a volume of interest of a subject when the probe (11) is positioned at a first position on the subject and tilted at a first angle relative to the volume of interest and the transducer elements (110) of the probe (11) have a first set of setting parameters, wherein the three-dimensional volume data of the volume of interest comprises ultrasound echo data of a plurality of scanning planes defined by the first set of setting parameters;

a processing unit (12) for determining a desired imaging plane (1) for the volume of interest in accordance with the three-dimensional volume data;

a transducer controller (13) for adjusting the transducer elements; and

a display (14);

characterized in that the processing unit (12) is further configured to:

a) determine a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements (110) having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane (1) without moving the probe; and

b) derive - if the result is YES- the second set of setting parameters, and - if the result is NO- derive a second position, a second angle and a third set of setting parameters such that when the probe (11) is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal transmitted from the transducer elements (110) having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane (1);

wherein the transducer controller (13) is configured to adjust the transducer elements in accordance with the derived second set of setting parameters if the result is YES, and to adjust the transducer elements in accordance with the derived third set of setting parameters if the result is NO; and
wherein the display (14) is configured to output- if the result is NO- an instruction to guide a user of the ultrasound imaging system (10) to move the probe (11) so as to be positioned at the second position and tilted at the second angle.

2. The ultrasound imaging system (10) according to claim 1, wherein
the display (14) is further configured to display an image of the desired imaging plane (1), which is reconstructed from the ultrasound echo data of the desired imaging plane (1).

3. The ultrasound imaging system (10) according to claim 1, wherein
the setting parameters of the transducer elements (110) comprise which transducer elements are to be enabled and the beam-forming parameters for the enabled transducer elements.

4. The ultrasound imaging system (10) according to any one of claims 1 to 3, wherein
the processing unit (12) is configured to automatically determine the desired imaging plane (1) for the volume of interest in accordance with the three-dimensional volume data, a clinical objective and a predetermined model.

5. The ultrasound imaging system (10) according to any one of claims 1 to 3, further comprising:

a user interface for receiving the user's input,

wherein the display (14) is further configured to display a plurality of images reconstructed from the three-dimensional volume data, and
wherein the processing unit (12) is further configured to determine the desired imaging plane (1) for the volume of interest in accordance with the user's manual selection based on the plurality of images reconstructed from the three-dimensional volume data.

6. The ultrasound imaging system according to claim 1, wherein
the processing unit (12) determines a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane (1) without moving the probe (11) based on the spatial positional relationship between the first position and the first angle of the probe and the desired imaging plane (1) and based on the layout of the transducer elements (110).

7. An ultrasound imaging method (20), comprising:

transmitting ultrasound signals and acquiring (21) three-dimensional volume data of a volume of interest of a subject with an ultrasound probe having a two-dimensional array of transducer elements, wherein the probe is positioned at a first position on the subject and tilted at a first angle relative to the volume of interest and the transducer elements of the probe have a first set of setting parameters, and wherein the three-dimensional volume data of the volume of interest comprises ultrasound echo data of a plurality of scanning planes defined by the first set of setting parameters; and
determining (22) a desired imaging plane for the volume of interest in accordance with the three-dimensional volume data;
characterized in that the method further comprises:

determining (23) a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe;
deriving (24) - if the result is YES - the second set of setting parameters, and - if the result is NO - deriving (26) a second position, a second angle and a third set of setting parameters such that when the probe is moved to the second position on the subject and tilted at the second angle relative to the volume of interest, the ultrasound signal

transmitted from the transducer elements having the third set of setting parameters is able to derive ultrasound echo data of the desired imaging plane; and

adjusting (25) the transducer elements in accordance with the derived second set of setting parameters if the result is YES, and outputting (27) an instruction to guide a user of the ultrasound imaging system to move the probe so as to be positioned at the second position and tilted at the second angle and adjusting the transducer elements in accordance with the derived third set of setting parameters if the result is NO.

8. The method (20) according to claim 7, further comprising:

displaying an image of the desired imaging plane, which is reconstructed from the ultrasound echo data of the desired imaging plane.

9. The method (20) according to any one of claims 7 and 8, wherein the desired imaging plane for the volume of interest is determined automatically in accordance with the three-dimensional volume data, a clinical objective and a predetermined model.

10. The method (20) according to any one of claims 7 and 8, wherein the desired imaging plane for the volume of interest is determined in accordance with the user's manual selection based on the plurality of images reconstructed from the three-dimensional volume data.

11. The method (20) according to claim 7, wherein the step of determining (23) a result whether there is a second set of setting parameters such that the ultrasound signal transmitted from the transducer elements having the second set of setting parameters is able to acquire ultrasound echo data of the desired imaging plane without moving the probe is based on the spatial positional relationship between the first position and the first angle of the probe and the desired imaging plane, and is based on the layout of the transducer elements.

Patentansprüche

1. Ultraschallbildgebungssystem (10), umfassend:

eine Ultraschallsonde (11) mit einem zweidimensionalen Array aus Wandlerelementen (110) zum Aussenden von Ultraschallsignalen und Erfassen von dreidimensionalen Volumendaten eines interessierenden Volumens eines Patienten, wenn die Sonde (11) an einer ersten Position auf dem Patienten positioniert und in einem ersten Winkel in Bezug auf das interessierende Volumen geneigt ist und die Wandlerelemente (110) der Sonde (11) einen ersten Satz von Einstellparametern haben, wobei die dreidimensionalen Volumendaten des interessierenden Volumens Ultraschallechodaten von einer Vielzahl von Abtastebenen umfassen, die durch den ersten Satz von Einstellparametern definiert werden;

eine Verarbeitungseinheit (12) zum Bestimmen einer gewünschten Bildgebungsebene (1) für das interessierende Volumen in Übereinstimmung mit den dreidimensionalen Volumendaten;

eine Wandlersteuereinheit (13) zum Anpassen der Wandlerelemente; und

eine Anzeige (14);

dadurch gekennzeichnet, dass die Verarbeitungseinheit (12) weiterhin konfiguriert ist zum:

a) Ermitteln eines Ergebnisses in Hinblick darauf, ob ein zweiter Satz von Einstellparametern vorliegt, sodass das von den Wandlerelementen (110) mit dem zweiten Satz von Einstellparametern ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten der gewünschten Bildgebungsebene (1) ohne Bewegen der Sonde zu erfassen; und

b) Ableiten - wenn das Ergebnis JA lautet- des zweiten Satzes von Einstellparametern, und - wenn das Ergebnis NEIN lautet - Ableiten einer zweiten Position, eines zweiten Winkels und eines dritten Satzes von Einstellparametern, sodass das von den Wandlerelementen (110) mit dem dritten Satz von Einstellparametern ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten der gewünschten Bildgebungsebene (1) abzuleiten, wenn die Sonde (11) zu der zweiten Position auf dem Patienten bewegt und in dem zweiten Winkel in Bezug auf das interessierende Volumen geneigt wird;

wobei die Wandlersteuereinheit (13) konfiguriert ist, um die Wandlerelemente in Übereinstimmung mit dem abgeleiteten zweiten Satz von Einstellparametern anzupassen, wenn das Ergebnis JA lautet, und um die Wandlerelemente in Übereinstimmung mit dem abgeleiteten dritten Satz von Einstellparametern anzupassen, wenn das Ergebnis NEIN lautet; und

wobei die Anzeige (14) konfiguriert ist, um - wenn das Ergebnis NEIN lautet - eine Anweisung zum Anleiten eines Benutzers des Ultraschallbildgebungssystems (10) auszugeben, die Sonde (11) so zu bewegen, dass sie an der zweiten Position positioniert und in dem zweiten Winkel geneigt wird.

2. Ultraschallbildgebungssystem (10) nach Anspruch 1, wobei
die Anzeige (14) weiterhin konfiguriert ist, um ein Bild der gewünschten Bildgebungsebene (1) anzuzeigen, das aus den Ultraschallechodaten der gewünschten Bildgebungsebene (1) rekonstruiert wird.

3. Ultraschallbildgebungssystem (10) nach Anspruch 1, wobei
die Einstellparameter der Wandlerelemente (110) umfassen, welche Wandlerelemente zu aktivieren sind, und die strahlformenden Parameter für die aktivierten Wandlerelemente.

4. Ultraschallbildgebungssystem (10) nach einem der Ansprüche 1 bis 3, wobei
die Verarbeitungseinheit (12) konfiguriert ist, um automatisch die gewünschte Bildgebungsebene (1) für das interessierende Volumen in Übereinstimmung mit den dreidimensionalen Volumendaten, einem klinischen Ziel und einem vorgegebenen Modell zu bestimmen.

5. Ultraschallsystem (10) nach einem der Ansprüche 1 bis 3, weiterhin umfassend:

eine Benutzerschnittstelle zum Empfangen der Eingabe des Benutzers, wobei die Anzeige (14) weiterhin konfiguriert ist, um eine Vielzahl von aus den dreidimensionalen Volumendaten rekonstruierten Bildern anzuzeigen, und

wobei die Verarbeitungseinheit (12) weiterhin konfiguriert ist, um die gewünschte Bildgebungsebene (1) für das interessierende Volume in Übereinstimmung mit der manuellen Auswahl des Benutzers basierend auf der Vielzahl von aus den dreidimensionalen Volumendaten rekonstruierten Bildern zu bestimmen.

6. Ultraschallbildgebungssystem nach Anspruch 1, wobei
die Verarbeitungseinheit (12) basierend auf der räumlichen Positionsbeziehung zwischen der ersten Position und dem ersten Winkel der Sonde und der gewünschten Bildgebungsebene (1) und basierend auf dem Layout der Wandlerelemente (110) ein Ergebnis in Hinblick darauf ermittelt, ob ein zweiter Satz von Einstellparametern vorliegt, sodass das von den Wandlerelementen mit dem zweiten Satz von Einstellparametern ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten der gewünschten Bildgebungsebene (1) ohne Bewegen der Sonde (11) zu erfassen.

7. Ultraschallbildgebungsverfahren (20), umfassend:

Aussenden von Ultraschallsignalen und Erfassen (21) von dreidimensionalen Volumendaten eines interessierenden Volumens eines Patienten mit einer Ultraschallsonde mit einem zweidimensionalen Array aus Wandlerelementen, wobei die Sonde an einer ersten Position auf dem Patienten positioniert und in einem ersten Winkel in Bezug auf das interessierende Volumen geneigt wird und die Wandlerelemente der Sonde einen ersten Satz von Einstellparametern haben, und wobei die dreidimensionalen Volumendaten des interessierenden Volumens Ultraschallechodaten von einer Vielzahl von Abtastebenen umfassen, die durch den ersten Satz von Einstellparametern definiert werden; und
Bestimmen (22) einer gewünschten Bildgebungsebene für das interessierende Volumen in Übereinstimmung mit den dreidimensionalen Volumendaten;
dadurch gekennzeichnet, dass das Verfahren weiterhin Folgendes umfasst:

Ermitteln (23) eines Ergebnisses in Hinblick darauf, ob ein zweiter Satz von Einstellparametern vorliegt, sodass das von den Wandlerelementen mit dem zweiten Satz von Einstellelementen ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten der gewünschten Bildgebungsebene ohne Bewegen der Sonde zu erfassen;
Ableiten (24) - wenn das Ergebnis JA lautet - des zweiten Satzes von Einstellparametern, und - wenn das Ergebnis NEIN lautet - Ableiten (26) einer zweiten Position, eines zweiten Winkels und eines dritten Satzes von Einstellparametern, sodass das von den Wandlerelementen mit dem dritten Satz von Einstellparametern ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten von der gewünschten Bildgebungsebene abzuleiten, wenn die Sonde zu der zweiten Position auf dem Patienten bewegt und in dem zweiten Winkel in Bezug auf das interessierende Volumen geneigt wird; und
Anpassen (25) der Wandlerelemente in Übereinstimmung mit dem abgeleiteten zweiten Satz von Einstellparametern, wenn das Ergebnis JA lautet, und Ausgeben (27) einer Anweisung zum Anleiten eines Benutzers des Ultraschallbildgebungssystems, die Sonde so zu bewegen, dass sie an der zweiten Position positioniert und in dem zweiten Winkel geneigt wird, und Anpassen der Wandlerelemente in Übereinstimmung

mit dem abgeleiteten dritten Satz von Einstellparametern, wenn das Ergebnis NEIN lautet.

8. Verfahren (20) nach Anspruch 7, weiterhin umfassend:

Anzeigen eines Bilds der gewünschten Bildgebungsebene, das aus den Ultraschallechodaten der gewünschten Bildgebungsebene rekonstruiert wird.

9. Verfahren (20) nach einem der Ansprüche 7 und 8, wobei
die gewünschte Bildgebungsebene für das interessierende Volumen automatisch in Übereinstimmung mit den dreidimensionalen Volumendaten, einem klinischen Ziel und einem vorgegebenen Modell bestimmt wird.

10. Verfahren (20) nach einem der Ansprüche 7 und 8, wobei
die gewünschte Bildgebungsebene für das interessierende Volumen in Übereinstimmung mit der manuellen Auswahl des Benutzers basierend auf der Vielzahl von aus den dreidimensionalen Volumendaten rekonstruierten Bildern bestimmt wird.

11. Verfahren (20) nach Anspruch 7, wobei
der Schritt des Ermittelns (23) eines Ergebnisses in Hinblick darauf, ob ein zweiter Satz von Einstellparametern vorliegt, sodass das von den Wandlerelementen mit dem zweiten Satz von Einstellparametern ausgesendete Ultraschallsignal in der Lage ist, Ultraschallechodaten der gewünschten Bildgebungsebene ohne Bewegen der Sonde zu erfassen, auf der räumlichen Positionsbeziehung zwischen der ersten Position und dem ersten Winkel der Sonde und der gewünschten Bildgebungsebene basiert, und auf dem Layout der Wandlerelemente basiert.

Revendications

1. Système d'imagerie à ultrasons (10), comprenant :

une sonde à ultrasons (11) avec une rangée à deux dimensions d'éléments transducteurs (110) pour transmettre des signaux à ultrasons et acquérir des données de volume en trois dimensions d'un volume d'intérêt d'un sujet quand la sonde (11) est positionnée dans une première position sur le sujet et inclinée selon un premier angle relativement au volume d'intérêt et les éléments de transducteur (110) de la sonde (11) ont un premier ensemble de paramètres de réglage, dans lequel les données de volume en trois dimensions du volume d'intérêt comprennent des donnée d'échos d'ultrason d'une pluralité de plans de balayage par le premier ensemble de paramètres de réglage ;
une unité de traitement (12) pour déterminer un plan d'imagerie souhaité (1) pour le volume d'intérêt, conformément aux données de volume en trois dimensions ;
un système de commande de transducteur (13) pour ajuster les éléments de transducteur ; et
un écran (14) ;
caractérisé en ce que l'unité de traitement (12) est en outre configurée pour :

a) déterminer un résultat indiquant s'il existe un second ensemble de paramètres de réglage de sorte que le signal à ultrasons transmis par les éléments de transducteur (110) ayant le second ensemble de paramètres de réglages soit en mesure d'acquérir les données d'écho d'ultrasons du plan d'imagerie souhaité (1) sans déplacer la sonde ; et
b) déduire - si le résultat est OUI - le second ensemble de paramètres de réglage, et - si le résultat est NON - déduire une seconde position, un second angle et un troisième ensemble de paramètres de réglage, de sorte que lorsque la sonde (11) est déplacée dans la seconde position sur le sujet et inclinée selon un second angle relatif au volume d'intérêt, le signal à ultrasons transmis par les éléments de transducteur (110) ayant le troisième ensemble de paramètres de réglage est en mesure d'obtenir des données d'écho d'ultrasons du plan d'imagerie souhaité (1) ;

dans lequel le système de commande de transducteur (13) est configuré pour ajuster les éléments de transducteur conformément au second ensemble de paramètres de réglages déduit si le résultat est OUI, et pour ajuster les éléments de transducteur conformément au troisième ensemble de paramètres de réglage déduit si le résultat est NON ; et
dans lequel l'écran (14) est configuré pour émettre - si le résultat est NON - une instruction pour guider l'utilisateur du système d'imagerie à ultrasons (10) afin de déplacer la sonde (11) de façon à ce qu'elle soit positionnée dans la seconde position et inclinée selon le second angle.

2. Système d'imagerie à ultrasons (10) selon la revendication 1, dans lequel
l'écran (14) est en outre configuré pour afficher une image du plan d'imagerie souhaité (1) qui est reconstituée à partir des données d'écho d'ultrasons du plan d'imagerie souhaité (1).

3. Système d'imagerie à ultrasons (10) selon la revendication 1, dans lequel
les paramètres de réglage des éléments de transducteur (110) comprennent les éléments de transducteur qui sont activés et les paramètres formant un faisceau pour les éléments de transducteur activés.

4. Système d'imagerie à ultrasons (10) selon l'une quelconque des revendications 1 à 3, dans lequel l'unité de traitement (12) est configurée pour déterminer automatiquement le plan d'imagerie souhaité (1) pour le volume d'intérêt, conformément aux données de volume en trois dimensions, à un objectif clinique et à un modèle prédéterminé.

5. Système d'imagerie à ultrasons (10) selon l'une quelconque des revendications 1 à 3, comprenant en outre
une interface utilisateur pour recevoir l'entrée de l'utilisateur,
dans lequel l'écran (14) est en outre configuré pour afficher une pluralité d'images reconstituées à partir des données de volume en trois dimensions, et
dans lequel l'unité de traitement (12) est en outre configurée pour déterminer le plan d'imagerie souhaité (1) pour le volume d'intérêt conformément à la sélection manuelle de l'utilisateur sur la base de la pluralité d'images reconstituées à partir des données de volume en trois dimensions.

6. Système d'imagerie à ultrasons selon la revendication 1, dans lequel
l'unité de traitement (12) détermine un résultat indiquant s'il existe un second ensemble de paramètres de réglages, de sorte que le signal à ultrasons transmis par les éléments de transducteur ayant le second ensemble de paramètres de réglage soit en mesure d'acquérir des données d'écho d'ultrasons du plan d'imagerie souhaité (1) sans déplacer la sonde (11), sur la base de la relation de position spatiale entre la première position et le premier angle de la sonde et le plan d'imagerie souhaité (1) et sur la base de la disposition des éléments de transducteur (110).

7. Procédé d'imagerie à ultrasons (20) comprenant :

la transmission de signaux à ultrasons et l'acquisition (21) de données de volume en trois dimensions d'un volume d'intérêt d'un sujet avec une sonde à ultrasons ayant une rangée à deux dimensions d'éléments de transducteur, dans lequel la sonde est positionnée dans une première position sur le sujet et inclinée selon un premier angle relativement au volume d'intérêt et les éléments de transducteur de la sonde ont un premier ensemble de paramètres de réglage, et dans lequel les données de volume en trois dimensions du volume d'intérêt comprennent des données d'écho d'ultrasons d'une pluralité de plans de balayage définis par le premier ensemble de paramètres de réglage, et
la détermination (22) d'un plan d'imagerie souhaité pour le volume d'intérêt, conformément aux données de volume en trois dimensions ;
caractérisé en ce que le procédé comprend en outre :

la détermination (23) d'un résultat indiquant s'il existe un second ensemble de paramètres de réglage, de sorte que le signal à ultrasons transmis par les éléments de transducteur ayant le second ensemble de paramètres de réglage soit en mesure d'acquérir des données d'écho d'ultrasons du plan d'imagerie souhaité sans déplacer la sonde ;
la déduction (24) - si le résultat est OUI - du second ensemble de paramètres de réglage, et - si le résultat est NON - la déduction (26) d'une seconde position, d'un second angle et d'un troisième ensemble de paramètres de réglage, de sorte que lorsque la sonde est déplacée vers la seconde position sur le sujet et inclinée selon le second angle relativement au volume d'intérêt, le signal à ultrasons transmis par les éléments de transducteur ayant le troisième ensemble de paramètres de réglage est en mesure de déduire des données d'écho d'ultrasons du plan d'imagerie souhaité ; et
l'ajustement (25) des éléments de transducteur conformément au second ensemble souhaité de paramètres de réglage si le résultat est OUI, et l'émission (27) d'instructions pour guider un utilisateur du système d'imagerie à ultrasons, afin qu'il déplace la sonde, de façon à ce qu'elle soit positionnée dans la seconde position et inclinée selon le second angle et l'ajustement des éléments de transducteur conformément au troisième ensemble déduit de paramètres de réglage si le résultat est NON.

8. Procédé (20) selon la revendication 7, comprenant en outre :

l'affichage d'une image du plan d'imagerie souhaitée, qui est reconstituée à partir des données d'écho d'ultrason du plan d'imagerie souhaité.

9. Procédé (20) selon l'une quelconque des revendications 7 et 8, dans lequel le plan d'imagerie souhaité pour le volume d'intérêt est déterminé automatiquement conformément aux données de volume en trois

dimensions, d'un objectif clinique et d'un modèle prédéterminé.

10. Procédé (20) selon l'une quelconque des revendications 7 et 8, dans lequel le plan d'imagerie souhaité pour le volume d'intérêt est déterminé conformément à la sélection du manuel de l'utilisateur, sur la base de la pluralité d'images reconstituées à partir des données de volume en trois dimensions.

11. Procédé (20) selon la revendication 7, dans lequel l'étape consistant à déterminer (23) un résultat indiquant s'il existe un second ensemble de paramètres de réglage, de sorte que le signal à ultrasons transmis par les éléments de transducteur ayant le second ensemble de paramètres de réglage soit en mesure d'acquérir les données d'écho d'ultrasons du plan d'imagerie souhaité sans déplacer la sonde, sur la base de la relation de position spatiale entre la première position et le premier angle de la sonde et le plan d'imagerie souhaité, et sur la base de la disposition des éléments de transducteur.

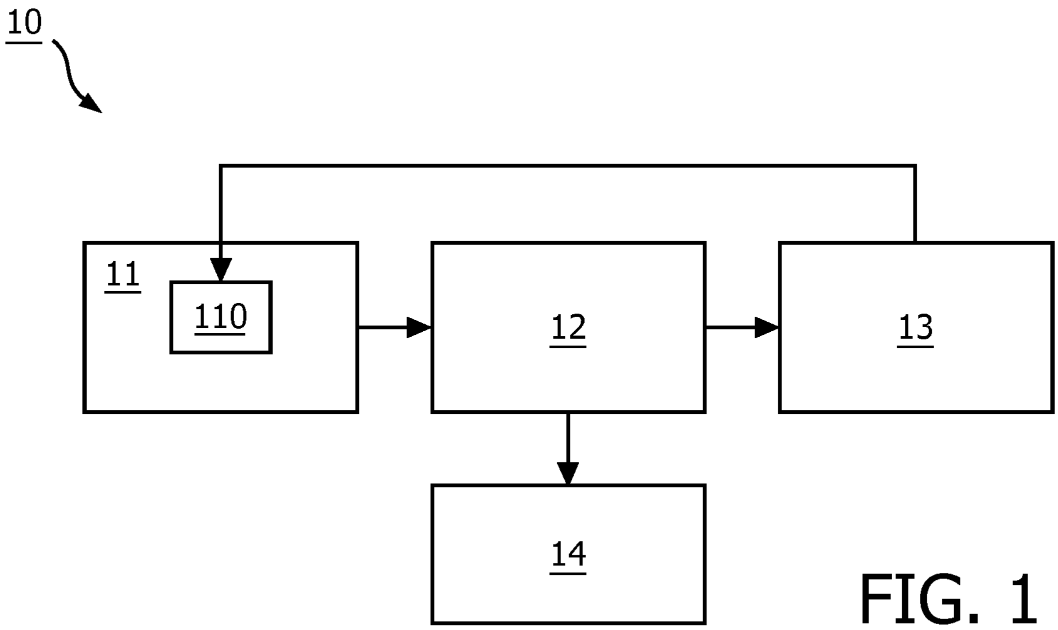

FIG. 1

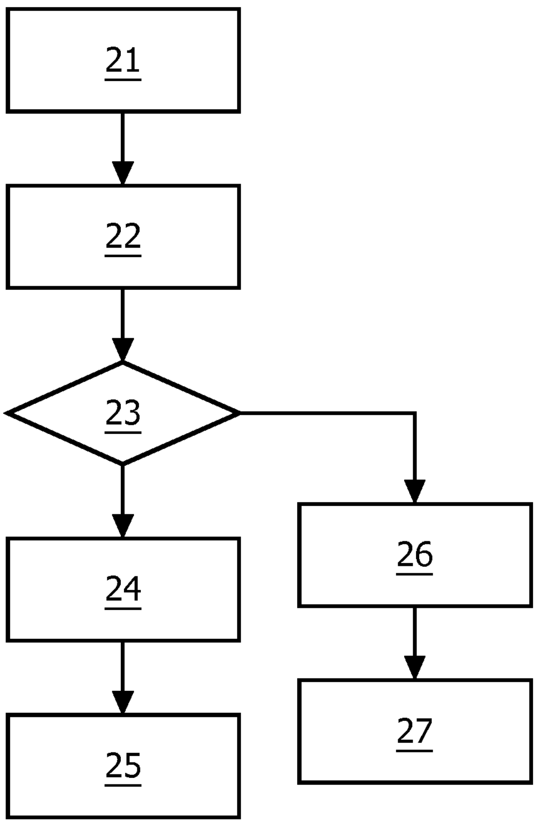

FIG. 2

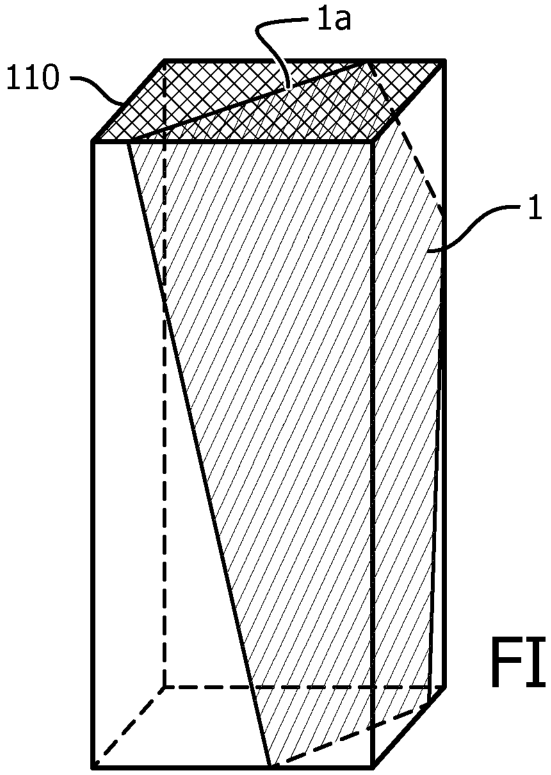

FIG. 3a

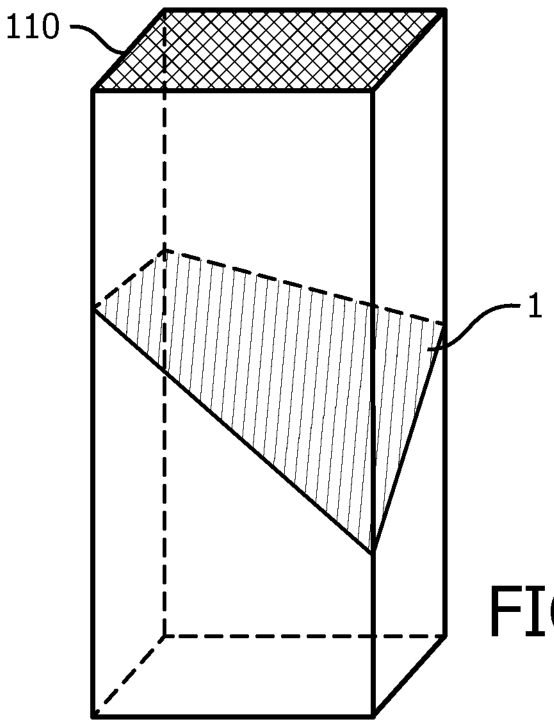

FIG. 3b

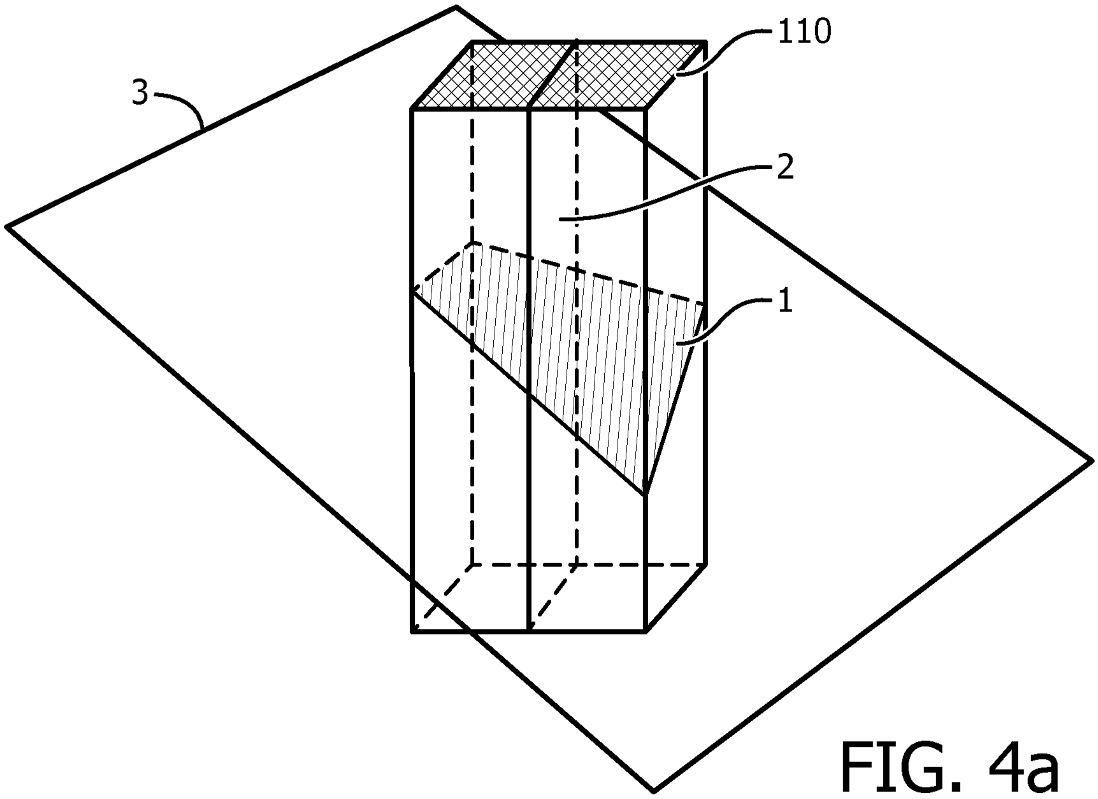

FIG. 4a

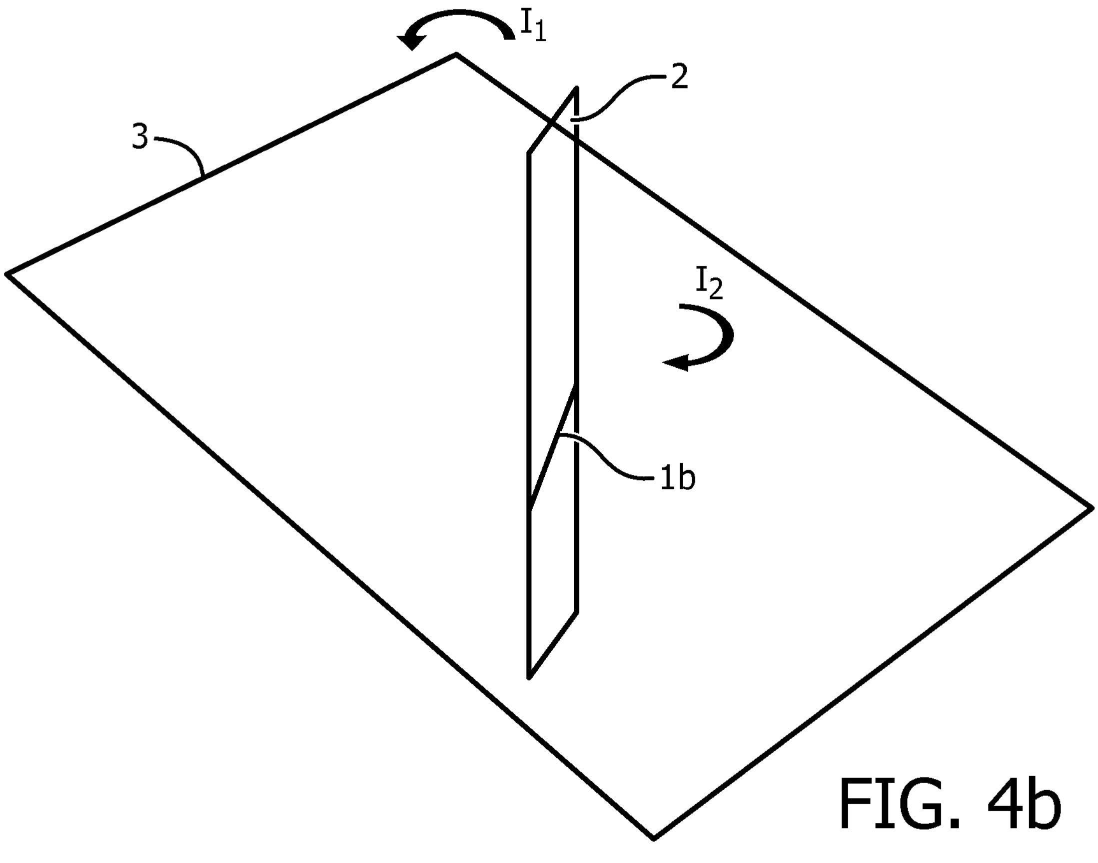

FIG. 4b

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	超声成像系统和超声成像方法

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IPC分类号	A61B8/08 A61B8/13 A61B8/14 A61B8/00
CPC分类号	A61B8/523 A61B8/14 A61B8/145 A61B8/4488 A61B8/4494 A61B8/465 A61B8/466 A61B8/469 A61B8/483 A61B8/54
代理机构(译)	STEFFEN , THOMAS
优先权	2014168419 2014-05-15 EP PCT/CN2014/071553 2014-01-27 WO
其他公开文献	EP3099243A1
外部链接	Espacenet

摘要(译)

本发明提供一种超声成像系统和超声成像方法，用于改善受试者感兴趣体积中的所需成像平面的成像质量。根据本发明，可以通过利用2D矩阵超声换能器的能力和/或超声探头的位置/取向的灵活性来直接扫描期望的成像平面。在一些情况下，可以调节换能器元件的设置参数，使得从换能器元件发送的超声信号能够在不移动探头的情况下导出期望成像平面的超声回波数据。在其他情况下，不能直接扫描所需的成像平面而不改变超声探头的位置/取向，超声探头的位置/取向可以通过用户交互来调整，即通过输出指导用户移动探头的指令，以便能够直接扫描所需的成像平面。以这种方式，不通过多个扫描平面的超声回波数据的内插（由换能器元件的设置参数确定）来重建期望的成像平面的图像，而是从超声回波重建它。所需成像平面本身的数据。换句话说，直接扫描期望的成像平面。因此，所需成像平面的图像质量得到改善，并且可以帮助医生更准确地进行诊断。

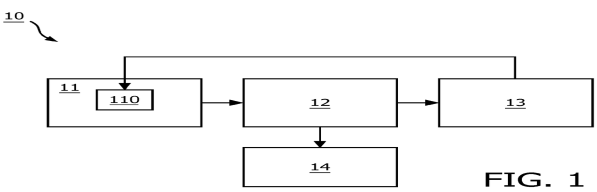

FIG. 1

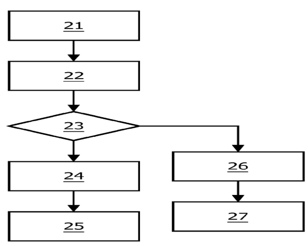

FIG. 2