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(54) **MPR SLICE SELECTION FOR VISUALIZATION OF CATHETER IN THREE-DIMENSIONAL ULTRASOUND**

AUSWAHL VON MPR-SLICES ZUR VISUALISIERUNG DES KATHETERS IM DREIDIMENSIONALEN ULTRASCHALL

CHOIX DE TRANCHES MPR POUR LA VISUALISATION DE CATHÉTER PAR ÉCHOGRAPHIE TRIDIMENSIONNELLE

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Description

[0001] The present invention generally relates to accurate visualization of an interventional tool during an interventional procedure, particularly an accurate visualization of a catheter during an interventional cardiac procedure. The present invention specifically relates to the visualization of the interventional tool in multi-planar reformatting ("MPR") images derived from a three-dimensional ultrasound image ("3D US").

[0002] Knowing a relative position of an interventional tool (e.g., a catheter) with respect to a pre-procedural planning scan (e.g., a magnetic resonance imaging ("MRI") scan or a computed tomography ("CT") scan) is important for accurate guidance in an interventional procedure, particularly an interventional cardiac procedure. Since X-ray fluoroscopic images provide very highly resolved images of the interventional tool during the procedure, image-guided systems known in the art for providing visual aid in guiding the interventional tool have concentrated on tracking a tip of the tool in fluoroscopic images and overlaying in the pre-procedural scan.

[0003] Increasingly, registering an ultrasound image ("2D US") or 3D US with X-ray imaging has augmented X-ray fluoroscopy as an aid for guiding an interventional procedure. The key role of the 2D US or the 3D US is to augment the pre-procedural scan with real time motion information, while the X-ray fluoroscopic image(s) provide high resolution visualization of the interventional tool in real time. Moreover, with the introduction of 3D US in real time, it is becoming possible to visualize the interventional tool more clearly in ultrasound, thereby enabling ultrasound-only guided interventions.

[0004] Localization of the tip of the interventional tool is of paramount importance for accurate navigation and targeting. In particular, for cardiovascular interventions, the visualization of the relationship of a tip and a body of the catheter with respect to the surrounding tissue is important for accurate navigation and targeting. However, visualization of the exact location and orientation of a tip and a body of an interventional tool is often difficult in 2D US or 3D US due to (1) image artifacts from the body of the interventional tool, (2) a limited view of 2D US or 3D US, and (3) out of plane issues involving the tip of the interventional tool going in and out of the 2D US image or 3D US image.

[0005] With the difficulty in visualizing the tip of the interventional device in 3D US, it is also difficult to define multi-planar reformatting ("MPR") views around the tip of the interventional device whereby the neighborhood of the tool tip including surrounding tissue is appropriately visualized.

[0006] US 2008/221446 discloses an ultrasound system comprising a position sensing module for detecting spatial information associated with a volume of data and a display for displaying first and second images based on the volume of data, wherein the first and second images comprise first and second portions of the volume of data. Further, the ultrasound system comprises a user interface for selecting a first image tracking point on the first image, wherein the first image tracking point is indicated on the first image with a first indicator, and an image tracking module for tracking the first image tracking point within the volume of data, wherein the image tracking module indicates on the display a spatial relationship of the first image tracking point to the second image.

[0007] The present invention provides systems for accurate real-time localizing of a tool tip in 3D US and for precise generation of the MPR views of the tool tip and surrounding neighborhood.

[0008] The invention in its general sense is a system as defined by independent claim 1. Further embodiments are defined by the dependent claims.

FIG. 1 illustrates an exemplary embodiment of an interventional tracking system in accordance with present invention.

FIG. 2 illustrates a flowchart representative of an interventional tracking method in accordance with the present invention.

FIGS. 3 and 4A-C illustrate a first exemplary implementation of the interventional method of FIG. 2 by the interventional tracking system of FIG. 1.

FIGS. 5 and 6A-B illustrate a second exemplary implementation of the interventional method of FIG. 2 by the interventional tracking system of FIG. 1.

FIGS. 7-9 illustrate a second exemplary implementation of the interventional method of FIG. 2 by the interventional tracking system of FIG. 1.

FIG. 10 illustrates a first exemplary embodiment of the interventional tracking system of FIG. 1.

FIG. 11 illustrates a first exemplary embodiment of the interventional tracking method of FIG. 2.

FIG. 12 illustrates an exemplary display of X-ray images and MPR images by the interventional tracking system of FIG. 10.

FIG. 13 illustrates a second exemplary embodiment of the interventional tracking system of FIG. 1.

FIG. 14 illustrates a second exemplary embodiment of the interventional tracking method of FIG. 2.

[0009] Disclosed are various systems and methods for visualizing a tool tip and surrounding neighborhood within MPR images derived from a 3D US image. As will be appreciated by those having ordinary skill in the art from the following descriptions of FIGS. 1-14, these methods are implemented by a MPR imaging module of the present invention.

[0010] FIG. 1 illustrates a system of the present invention employing 3D ultrasound imaging system, an interventional tool 30 and a MPR imaging device 40.

[0011] For purposes of the present invention, the 3D US imaging system is broadly defined herein as including a 3D US imaging device 21 for controlling an operation of 3D US probe 20 structurally configured for generating an ultrasound volume image ("USI") 22 of an anatomical region (e.g., cardiac region of a body). Examples of the 3D US imaging system include, but are not limited to, any type of 3D ultrasound imaging system utilizing a 3D TEE probe. In one embodiment, the iE33 intelligent echo system commercially sold by Philips Healthcare may serve as the 3D US imaging system.

[0012] For purposes of the present invention, interventional tool 30 is broadly defined herein as any type of tool, instrument or device structurally configured for performing specific actions of carrying out desired effects during any type of interventional procedure (e.g., interventional cardiology). For purposes of an interventional procedure, two or more image tracking points 31 are defined on the tip area or body of interventional device 30. In one embodiment, one of the tracking points is a tip of interventional device 30. In a second embodiment, each image tracking point 31 is defined by a sensor located in the tip area and/or body of interventional device 30. Examples of the sensor include, but are not limited to, an electromagnetic sensor, an optical sensor or a shape tracking sensor (e.g., a sensor making use of Fiber-Bragg gratings, Rayleigh scattering, backscattering, force sensing using optical fibers or measurement of deformities in optical fiber to track shape or location).

[0013] For purposes of the present invention, MPR imaging module 40 is broadly defined herein as any structural configuration of hardware, software and/or firmware for generating a MPR image 41 from ultrasound volume image 22 whereby an imaging tracking point 31 of interventional tool 30 serves as an origin of MPR image 41. In practice, MPR image 41 may have any orientation relative to the imaging tracking point 31 and may have any orientation within ultrasound volume image 22. Also in practice, MPR imaging module 40 may be integrated within ultrasound imaging device 21 or any other type of imaging or display device suitable for an interventional procedure.

[0014] To facilitate an understanding of MPR imaging module 40, a description and exemplarily implementation of an interventional tracking method.

[0015] FIG. 2 illustrates a flowchart 50 representative of the interventional tracking method. A stage S51 of flowchart 50 encompasses an identification of two or more image tracking points 31 of interventional tool 30 within ultrasound volume image 22, and a stage S52 of flowchart 50 encompasses a generation of one or more MPR images 41 with each identified image tracking point 31 serving as an origin of one of the MPR images 41.

[0016] For example, FIG. 3 shows an identification of a tip 63 of an interventional tool 62 within an ultrasound volume image 60 of an anatomical region including tissue 61, and the identified tip 63 serves as an origin of orthogonal MPR images 64-66 as shown in respective FIGS. 4A-4C. As a result, tip 63 of interventional tool 62 as well as neighboring portions of tissue 61 are accurately visualized in MPR images 64-66.

[0017] During the interventional procedure, MPR images 64-66 are continually updated as interventional tool 62 is navigated within the anatomical region and/or the ultrasound probe is moved relative to the anatomical region. To maintain an accurate visualization of tip 63 and neighboring portions of tissue 61, MPR image 64 has a fixed parallel relationship with plane XY of ultrasound volume image 60, MPR image 65 has a fixed parallel relationship with plane YZ of ultrasound volume image 60 and MPR image 66 has a fixed parallel relationship with plane XZ of ultrasound volume image 60.

[0018] By further example, FIG. 5 shows an identification of an electromagnetic sensor 72 of an interventional tool 71 within an ultrasound volume image 70 of an anatomical region and the identified sensor 72 serves as an origin of MPR images 73 and 74 as shown in respective FIGS. 6A and 6B. Electromagnetic sensor 72 is located within a tip section of interventional tool 71. As a result, the tip interventional tool 72 as well as neighboring portions of any tissue within the anatomical region are accurately visualized in MPR images 73 and 74. Please note tissue is not shown in FIG. 5 for purposes of illustrating sensor coordinate system $X_sY_sZ_s$.

[0019] During the interventional procedure, MPR images 73 and 74 are continually updated as interventional tool 71 is navigated within the anatomical region and/or the ultrasound probe is moved relative to the anatomical region. To maintain an accurate visualization of the tip of interventional tool 71 and neighboring portions of tissue, MPR image 73 has a fixed parallel relationship with plane X_sZ_s of the sensor coordinate system and MPR image 74 has a fixed parallel relationship with plane Y_sZ_s of the sensor coordinate system.

[0020] By further example, FIG. 7 illustrates an ultrasound probe 80 generating an ultrasound volume image 81 relative to an infarct region 90 of a heart. An interventional tool 100 has a defined spacing of electromagnetic sensors 110-113 relative to a tip of interventional tool 100. Three (3) MPR images 82-84 are generated with respective sensors 110-112 serving as the origin of MPR images 82-83 with each MPR image 82-84 being normal to the respective sensors 110-112.

[0021] To visualize both the tip and the body of interventional tool 100, MPR images 82-84 are arranged in a stack formation whereby interventional tool 100 is axially aligned. For instances whereby interventional tool 100 has a non-linear orientation within ultrasound volume image 81, the stacking of MPR images 82-84 warps ultrasound volume image 81 into an ultrasound volume image 85 as shown in FIG. 8. Ultrasound volume image 85 represents a centric rectangular shape having a dynamic frame of reference with tool 100 as its axis and the tip of tool 100 on one of its edges. As such, in practice, ultrasound volume image 85 may be utilized for various purposes.

[0022] In one embodiment, ultrasound volume image 85 may be resliced into one or more arbitrary MPR images containing a portion of the body of interventional tool 100, such as, for example MPR images 86 and 87 as shown in FIG. 8. This reslicing of ultrasound volume image 85 provides real-time soft tissue context around the body of interventional tool 100.

[0023] In a second embodiment, a target volume may be segmented from a pre-operative scan and then overlaid on ultrasound volume image 85 to aid in targeting the volume.

[0024] In a third embodiment, a pre-operative or an intra-operative scan (e.g., a MRI scan or a CT scan) from an imaging modality registered with electromagnetic frame of reference may be fused with ultrasound volume image 85, such as, for example, a fusion 87 of scan images 120-122 with MPR images 82-84 as shown in FIG. 9.

[0025] In a fourth embodiment, instead of showing the entire ultrasound image volume 85 within the scan fusion 87, only the axis of ultrasound volume image 85 may be visualized along with a target volume rendered in the space of the ultrasound volume image 85. This will hide the ultrasound data, but use the ultrasound data in the background to move the target volume in real-time.

[0026] To further facilitate an understanding of MPR imaging module 40, a description and exemplarily implementation of various interventional tracking systems of the present invention will now be described herein.

[0027] FIG. 10 illustrates an interventional tracking system employing an X-ray imaging system, an embodiment of 3D US imaging system of FIG. 1 and an embodiment of MPR imaging device 40 of FIG. 1.

[0028] For purposes of the present invention, the X-ray imaging system is broadly defined herein as including an X-ray imaging device 130 for controlling an operation of an X-ray source 131 and an X-ray detector 132 structurally configured for generating a X-ray image ("XRI") 135 of an anatomical region (e.g., a cardiac region) represented by a volume and/or for controlling an operation of an X-ray source 133 and an X-ray detector 134 structurally configured for generating a X-ray image ("XRI") 136 of anatomical region 91. In practice, components 130-132 exclusive of components 133 and 134 represent a monoplane X-ray system of any type, and components 130-134 collectively represent a bi-plane X-ray system of any type. Examples of the X-ray imaging system include, but are not limited to, any type of X-ray system for performing a cardiac interventional procedure. In one embodiment, an X-ray system from the Allure Xper series commercially sold by Philips Medical Systems may serve as the X-ray imaging system.

[0029] In operation, an interventional tracking method represented by a flowchart 140 shown in FIG. 11 is executed for purposes of generating MPR images of a portion or an entirety of a catheter 30a within a cardiac anatomical region 91 as derived from an ultrasound volume image 22 and X-ray images 135 and 136.

[0030] Specifically, referring to FIGS. 10 and 11, upon a catheter 30a being inserted within a cardiac anatomical region 91, a stage S141 of flowchart 140 encompasses an X-ray image acquisition by X-Ray imaging device 130 of catheter 30a at a 1st gantry angle during a specified cardiac phase (e.g., an end diastole phase) and a specified respiratory phase (e.g., an end respiratory phase) using known cardiac and respiratory gating techniques, and a stage S142 of flowchart 140 encompasses a manual or automatic segmentation by MPR imaging module 40a of a catheter tip 31a in the X-ray image acquired during stage S141.

[0031] For a monoplane X-ray imaging system, a stage S143 of flowchart 140 encompasses an X-ray image acquisition by X-Ray imaging device 130 of catheter 30a at a 2nd gantry angle during the same specified cardiac phase and the same specified respiratory phase using known cardiac and respiratory gating techniques, and a stage S144 of flowchart 140 encompasses a manual or automatic segmentation by MPR imaging module 40a of catheter tip 31a in the X-ray image acquired during stage S143.

[0032] For a biplane X-ray imaging system, stages S141/S142 and stages S143/S144 may be executed simultaneously.

[0033] For either X-ray imaging system, a corresponding 3D location of catheter tip 31a in the 2D X-ray coordinate system is reconstructed by MPR imaging module 40a during a stage S145 of flowchart 140. In one embodiment of stage S145, a known epipolar constraint is utilized to reconstruct the 3D location of catheter tip 31a in the 2D X-ray coordinate system.

[0034] Thereafter, during a stage S146 of flowchart 140, a reconstructed 2D X-ray coordinate location of catheter tip 31a is converted into a 3D US real-time coordinate location by MPR imaging module 40a using system calibration and real-time tracking. In one embodiment of stage S146, a manual alignment is used as the basis for the conversion. In a second embodiment of stage S146, a known electromagnetic tracking technique is used as the basis for the conversion.

[0035] A stage S147 of flowchart 140 encompasses MPR imaging module 40a utilizing the 3D US real time coordinate location of catheter tip 31a as an origin of two or more MPR images. For example, as shown in FIG. 12, catheter tip 31a is identified in X-RAY images 135a and 136a, the 2D X-ray coordinates of catheter tip 31a are converted into 3D US real-time coordinate location of catheter tip 31a, and MPR images 41a are generated with the 3D US real-time coordinate location serving as the origin of MPR images 41a of catheter tip 31a.

[0036] Referring back to FIGS. 10 and 11, upon the first execution of stage S147, flowchart 140 may return to stages S141 and S143 to update the 3D US real-time coordinate location of catheter tip 31a and therefore update the MPR images. This allows for accurate tracking of catheter tip 31a as catheter 30a is navigated within cardiac anatomical region 91 and/or the ultrasound probe 20a is moved relative to cardiac anatomical region 91. Stages S141-S147 will cycle until the procedure is completed.

[0037] FIG. 13 illustrates an interventional tracking system employing an embodiment of 3D US imaging system of FIG. 1, a tracking system and an embodiment of MPR imaging device 40 of FIG. 1.

[0038] For purposes of the present invention, the tracking system is broadly defined herein as any system including one or more position probe sensors 23 attached to ultrasound probe 20a, one or more position tool sensors 32(1)-(4) attached to catheter 30a and a global tracking device 150 structurally configured for tracking position sensors 23 and 32(1)-(4) within a global coordinate system. Examples of the tracking system include, but are not limited to, any type of electromagnetic tracking system, any type of optical tracking system, and any type of shape sensing system (e.g., optical fiber). In one embodiment, the Aurora™ Electromagnetic Tracking System commercially sold by NDI may serve as an electromagnetic tracking system.

[0039] In practice, position sensors 23 and 32(1)-(4) may have any required degrees of freedom ("DOF"), such as, for example, five (5) DOF or six (6) DOF.

[0040] In operation, an interventional tracking method represented by a flowchart 160 shown in FIG. 14 is executed for purposes of generating MPR images of a portion or an entirety of a catheter 30a within a cardiac anatomical region 91 as derived from an ultrasound volume image 22 and tracking of position sensor(s) 23 and 32 within a global coordinate system

[0041] Specifically, referring to FIG. 14, a stage S161 of flowchart 160 encompasses a calibration of ultrasound probe 20a to a coordinate space of position tool sensor 23 as known in the art, and a stage S162 of flowchart 160 encompasses a calibration of catheter 30a to a coordinate space of each position probe sensor 32 as known in the art.

[0042] A stage S163 of flowchart 160 encompasses a registration of the calibrations to the global coordinate system as known in the art whereby the tip and body of catheter 30a may be registered to corresponding points in the ultrasound volume image 22.

[0043] A stage S164 of flowchart 160 encompasses a generation of ultrasound volume image 22 as catheter 30a is being introduced into and navigated within cardiac anatomical region 91.

[0044] A stage S165 of flowchart 160 encompasses a generation of MPR images based on the registration of the calibrations to the global coordinate system. More particularly, a tip of catheter 30a may be identified in the global coordinate system and thus in ultrasound volume image 22 whereby MPR images may be generated with the catheter tip serving as the origin, such as, for example, MPR images 73 and 74 shown in FIG. 6. Concurrently or alternatively, sensor 32 along the body of catheter 30a may be identified in the global coordinate system and thus in ultrasound volume image 22 whereby MPR images may be generated with the sensors 32 serving as origins, such as, for example, MPR images 82-84 shown in FIGS. 7-9. A warped ultrasound image volume may then be generated as previously described herein in connection with FIGS. 8 and 9.

[0045] Upon the first execution of stage S165, flowchart 140 may return to a cycle of stages S164-S165 to update the MPR images. This allows for accurate tracking of the catheter tip and body as catheter 30a is navigated within cardiac anatomical region 91 and/or the ultrasound probe 20a is moved relative to cardiac anatomical region 91. Stages S164-S165 will cycle until the procedure is completed.

[0046] In practice, only one position probe sensor 32 may be employed when exclusively tracking the tip of catheter 30a.

[0047] From the description of FIGS. 1-14, those having skill in the art will have a further appreciation on how to implement systems and methods of the present invention for any interventional procedure.

[0048] In practice, any number of X-ray imaging devices, 3D US imaging device and a MPR imaging module may be integrated into a single device.

Claims

1. A system, comprising:

an interventional tool (30) having at least twoimage tracking points (31);
an ultrasound imaging system including an ultrasound probe (20) operable for generating an ultrasound volume image (22) of at least a portion of the interventional tool (30) within an anatomical region; and
a multi-planar reformatting imaging module (40) operable for generating at least two multi-planar reformatting images (41) of the at least a portion of the interventional tool (30) within the anatomical region, each multi-planar reformatting image (41) being normal to the interventional tool (30) relative to one of the tracking points (31), wherein a generation of the at least two multi-planar reformatting images (41) includes:

an identification of each image tracking point (31) within the ultrasound volume image (22); and
a utilization of each identified image tracking point (31) as an origin of at least one of the least two multi-planar reformatting images (41).

2. The system of claim 1, wherein the interventional tool (30) is a catheter.

3. The system of claim 1, wherein one of the imaging tracking points (31) is located within a tip section of the interventional tool (30).

4. The system of claim 1, wherein the at least two multi-planar reformatting images (41) are spaced relative to a tip section of the interventional tool (30).

5. The system of claim 1, wherein each multi-planar reformatting image (41) has a fixed orientation within the ultrasound volume image (22).

6. The system of claim 1, wherein the multi-planar reformatting imaging module (40) is further operable for dynamically updating the least two multi-planar reformatting images (41) as the interventional tool (30) is navigated within the anatomical region.

7. The system of claim 1, wherein the multi-planar reformatting imaging module (40) is further operable for dynamically updating the least two multi-planar reformatting images (41) as the ultrasound probe (20) is moved relative to the anatomical region.

8. The system of claim 1, further comprising:
an X-ray imaging system operable for generating at least two X-ray images of the at least a portion of the interventional tool (30) within the anatomical region, wherein the identification of each imaging tracking point (31) within the ultrasound volume image (22) includes:

an identification of each imaging tracking point (31) within the at least two X-ray images; and
a conversion of each identified imaging tracking point (31) within the at least two X-ray images to the ultrasound volume image (22).

9. The system of claim 1, further comprising:
a global tracking system including at least one tool sensor integrated with the interventional tool (30), wherein each tool sensor defines one of the at least two imaging tracking points (31).

10. The system of claim 9, wherein each tool sensor is an electromagnetic sensor.

11. The system of claim 9,
wherein the global tracking system further includes at least one probe sensor integrated with the ultrasound probe (20); and
wherein the identification of each imaging tracking point (31) within the ultrasound volume image (22) includes a co-registration of each tool sensor and each probe sensor to a global tracking coordinate system.

12. The system of claim 1, further comprising:
a global tracking system including a shape tracking sensor integrated with the interventional tool (30), wherein the shape tracking sensor defines each of the at least two imaging tracking points (31).

13. The system of claim 1, wherein the multi-planar reformatting imaging module (40) is further operable for stacking the at least two multi-planar reformatting images (41) to form a warped ultrasound volume image (22) relative to an axial alignment of the at least a portion of the interventional tool (30) within the ultrasound volume image (22).

14. The system of claim 13, wherein the multi-planar reformatting imaging module (40) is further operable for slicing the warped ultrasound volume image (22) into at least one additional multi-planar reformatting image (41) to visualize the at least portion of the interventional tool (30) and surrounding portions of the anatomical region.

15. The system of claim 13, further comprising:
an image modality operable for generating a scan image of the anatomical region,
wherein the multi-planar reformatting imaging module (40) is further operable for fusing the warped ultrasound volume image (22) and the scan image.

Patentansprüche

1. System, umfassend:

ein interventionelles Tool (30), das mindestens zwei Bildnachverfolgungspunkte (31) aufweist;
ein Ultraschallbildgebungssystem, das eine Ultraschallsonde (20) beinhaltet, die zum Erzeugen eines Ultraschallvolumenbildes (22) mindestens eines Abschnitts des interventionellen Tools (30) innerhalb einer anatomischen Region funktionsbereit ist; und
ein multiplanares Reformatierungsbildgebungsmodul (40), das zum Erzeugen von mindestens zwei multiplanaren Reformatierungsbildern (41) des mindestens einen Abschnitts des interventionellen Tools (30) innerhalb der anatomischen Region funktionsbereit ist, wobei jedes multiplanare Reformatierungsbild (41) relativ zu einem der Nachverfolgungspunkte (31) normal zu dem interventionellen Tool (30) ist, wobei eine Erzeugung der mindestens zwei multiplanaren Reformatierungsbilder (41) Folgendes beinhaltet:

eine Identifizierung jedes Bildnachverfolgungspunktes (31) innerhalb des Ultraschallvolumenbildes (22); und
eine Nutzung jedes identifizierten Bildnachverfolgungspunktes (31) als Ursprung mindestens eines der mindestens zwei multiplanaren Reformatierungsbilder (41).

2. System nach Anspruch 1, wobei das interventionelle Tool (30) ein Katheter ist.

3. System nach Anspruch 1, wobei einer der Bildgebungsnachverfolgungspunkte (31) innerhalb eines Spitzenabschnitts des interventionellen Tools (30) angeordnet ist.

4. System nach Anspruch 1, wobei die mindestens zwei multiplanaren Reformatierungsbilder (41) relativ zu einem Spitzenabschnitt des interventionellen Tools (30) beabstandet sind.

5. System nach Anspruch 1, wobei jedes multiplanare Reformatierungsbild (41) eine feste Orientierung innerhalb des Ultraschallvolumenbildes (22) aufweist.

6. System nach Anspruch 1, wobei das multiplanare Reformatierungsbildgebungsmodul (40) weiter zum dynamischen Aktualisieren der mindestens zwei multiplanaren Reformatierungsbilder (41) funktionsbereit ist, wenn das interventionelle Tool (30) innerhalb der anatomischen Region navigiert wird.

7. System nach Anspruch 1, wobei das multiplanare Reformatierungsbildgebungsmodul (40) weiter zum dynamischen Aktualisieren der mindestens zwei multiplanaren Reformatierungsbilder (41) funktionsbereit ist, wenn die Ultraschallsonde (20) relativ zu der anatomischen Region navigiert wird.

8. System nach Anspruch 1, weiter umfassend: ein Röntgenbildgebungssystem, das zum Erzeugen von mindestens zwei Röntgenbildern des mindestens einen Abschnitts des interventionellen Tools (30) innerhalb der anatomischen Region funktionsbereit ist, wobei die Identifizierung jedes Bildgebungsnachverfolgungspunktes (31) innerhalb des Ultraschallvolumenbildes (22) Folgendes beinhaltet:

eine Identifizierung jedes Bildgebungsnachverfolgungspunktes (31) innerhalb der mindestens zwei Röntgenbilder; und
eine Umwandlung jedes identifizierten Bildgebungsnachverfolgungspunktes (31) innerhalb der mindestens zwei Röntgenbilder in das Ultraschallvolumenbild (22).

9. System nach Anspruch 1, weiter umfassend: ein globales Nachverfolgungssystem, das mindestens einen in das interventionelle Tool (30) integrierten Tool-Sensor beinhaltet, wobei jeder Tool-Sensor einen der mindestens zwei Bildgebungsnachverfolgungspunkte (31) definiert.

10. System nach Anspruch 9, wobei jeder Tool-Sensor ein elektromagnetischer Sensor ist.

11. System nach Anspruch 9, wobei das globale Nachverfolgungssystem weiter mindestens einen in die Ultraschallsonde (20) integrierten Sondensensor beinhaltet; und wobei die Identifizierung jedes Bildgebungsnachverfolgungspunktes (31) innerhalb des Ultraschallvolumenbildes (22) eine Co-Registrierung jedes Tool-Sensors und jedes Sondensensors mit einem globalen Nachverfolgungskoordinatensystem beinhaltet.

12. System nach Anspruch 1, weiter umfassend: ein globales Nachverfolgungssystem, das einen in das interventionelle Tool (30) integrierten Formnachverfolgungssensor beinhaltet, wobei der Formnachverfolgungssensor jeden der mindestens zwei Bildgebungsnachverfolgungspunkte (31) definiert.

13. System nach Anspruch 1, wobei das multiplanare Reformatierungsbildgebungsmodul (40) weiter zum Schichten der mindestens zwei multiplanaren Reformatierungsbilder (41) funktionsbereit ist, um relativ zu einer axialen Ausrichtung des mindestens einen Abschnitts des interventionellen Tools (30) innerhalb des Ultraschallbildes (22) ein verdrehtes Ultraschallvolumenbild (22) zu bilden.

14. System nach Anspruch 13, wobei das multiplanare Reformatierungsbildgebungsmodul (40) weiter zum Schneiden des verdrehten Ultraschallvolumenbildes (22) in mindestens ein zusätzliches multiplanares Reformatierungsbild (41) funktionsbereit ist, um den mindestens einen Abschnitt des interventionellen Tools (30) und umgebende Abschnitte der anatomischen Region zu visualisieren.

15. System nach Anspruch 13, weiter umfassend:

eine Bildmodalität, die zum Erzeugen eines Scan-Bildes der anatomischen Region funktionsbereit ist,
wobei das multiplanare Reformatierungsbildgebungsmodul (40) weiter zum Vereinigen des verdrehten Ultraschallvolumenbildes (22) und des Scan-Bildes funktionsbereit ist.

Revendications

1. Système, comprenant :

un outil d'intervention (30) ayant au moins deux points de suivi d'image (31) ;
un système d'imagerie à ultrasons incluant une sonde à ultrasons (20) pouvant fonctionner pour générer une image de volume d'ultrasons (22) d'au moins une partie de l'outil d'intervention (30) dans une région anatomique ; et
un module d'imagerie de reformatage multiplanaire (40) pouvant fonctionner pour générer au

moins deux images de reformatage multiplanaire (41) de l'au moins une partie de l'outil d'intervention (30) dans la région anatomique, chaque image de reformatage multiplanaire (41) étant perpendiculaire à l'outil d'intervention (30) par rapport à un des points de suivi (31), dans lequel une génération des au moins deux images de reformatage multiplanaire (41) inclut :

une identification de chaque point de suivi d'image (31) dans l'image de volume d'ultrasons (22) ; et
une utilisation de chaque point de suivi d'image identifié (31) comme une origine d'au moins une des au moins deux images de reformatage multiplanaire (41).

2. Système selon la revendication 1, dans lequel l'outil d'intervention (30) est un cathéter.

3. Système selon la revendication 1, dans lequel un des points de suivi d'imagerie (31) est situé dans une section d'extrémité de l'outil d'intervention (30).

4. Système selon la revendication 1, dans lequel les au moins deux images de reformatage multiplanaire (41) sont espacées par rapport à une section d'extrémité de l'outil d'intervention (30).

5. Système selon la revendication 1, dans lequel chaque image de reformatage multiplanaire (41) a une orientation fixe dans l'image de volume d'ultrasons (22).

6. Système selon la revendication 1, dans lequel le module d'imagerie de reformatage multiplanaire (40) peut en outre fonctionner pour mettre à jour dynamiquement les au moins deux images de reformatage multiplanaire (41) tandis que l'outil d'intervention (30) est dirigé dans la région anatomique.

7. Système selon la revendication 1, dans lequel le module d'imagerie de reformatage multiplanaire (40) peut en outre fonctionner pour mettre à jour dynamiquement les au moins deux images de reformatage multiplanaire (41) tandis que la sonde à ultrasons (20) est déplacée par rapport à la région anatomique.

8. Système selon la revendication 1, comprenant en outre :
un système d'imagerie à rayons X pouvant fonctionner pour générer au moins deux images à rayons X de l'au moins une partie de l'outil d'intervention (30) dans la région anatomique, dans lequel l'identification de chaque point de suivi d'imagerie (31) dans l'image de volume d'ultrasons (22) inclut :

une identification de chaque point de suivi d'imagerie (31) dans les au moins deux images à rayons X ; et
une conversion de chaque point de suivi d'imagerie identifié (31) dans les au moins deux images à rayons X en l'image de volume d'ultrasons (22).

9. Système selon la revendication 1, comprenant en outre :
un système de suivi global incluant au moins un détecteur d'outil intégré à l'outil d'intervention (30), dans lequel chaque détecteur d'outil définit une des au moins deux points de suivi d'imagerie (31).

10. Système selon la revendication 9, dans lequel chaque détecteur d'outil est un détecteur électromagnétique.

11. Système selon la revendication 9,
dans lequel le système de suivi global inclut en outre au moins un détecteur de sonde intégré à la sonde à ultrasons (20) ; et
dans lequel l'identification de chaque point de suivi d'imagerie (31) dans l'image de volume d'ultrasons (22) inclut un co-enregistrement de chaque détecteur d'outil et de chaque détecteur de sonde dans un système de coordonnées de suivi global.

12. Système selon la revendication 1, comprenant en outre :
un système de suivi global incluant un détecteur de suivi de forme intégré à l'outil d'intervention (30), dans lequel le détecteur de suivi de forme définit chacun des au moins deux points de suivi d'imagerie (31).

13. Système selon la revendication 1, dans lequel le module d'imagerie de reformatage multiplanaire (40) peut en outre fonctionner pour empiler les au moins deux images de reformatage multiplanaire (41) pour former une image de volume d'ultrasons déformée (22) par rapport à un alignement axial de l'au moins une partie de l'outil d'intervention (30) dans l'image de volume d'ultrasons (22).

14. Système selon la revendication 13, dans lequel le module d'imagerie de reformatage multiplanaire (40) peut en outre fonctionner pour couper l'image de volume d'ultrasons déformée (22) en au moins une image de reformatage multiplanaire supplémentaire (41) pour visualiser l'au moins une partie de l'outil d'intervention (30) et des parties environnantes de la région anatomique.

15. Système selon la revendication 13, comprenant en outre :

une modalité d'image pouvant fonctionner pour générer une image de balayage de la région anatomique,
dans lequel le module d'imagerie de reformatage multiplanaire (40) peut en outre fonctionner pour fusionner l'image de volume d'ultrasons déformée (22) et l'image de balayage.

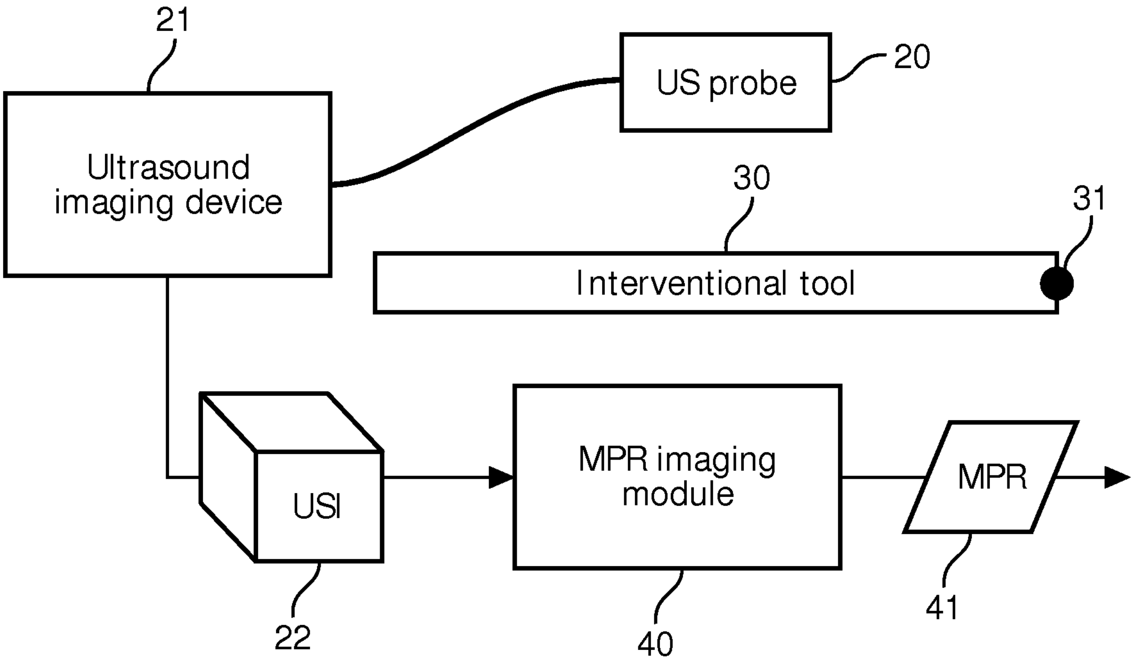
21
US probe
20
Ultrasound imaging device
30
31
Interventional tool
USI
MPR imaging module
MPR
22
40
41

FIG. 1

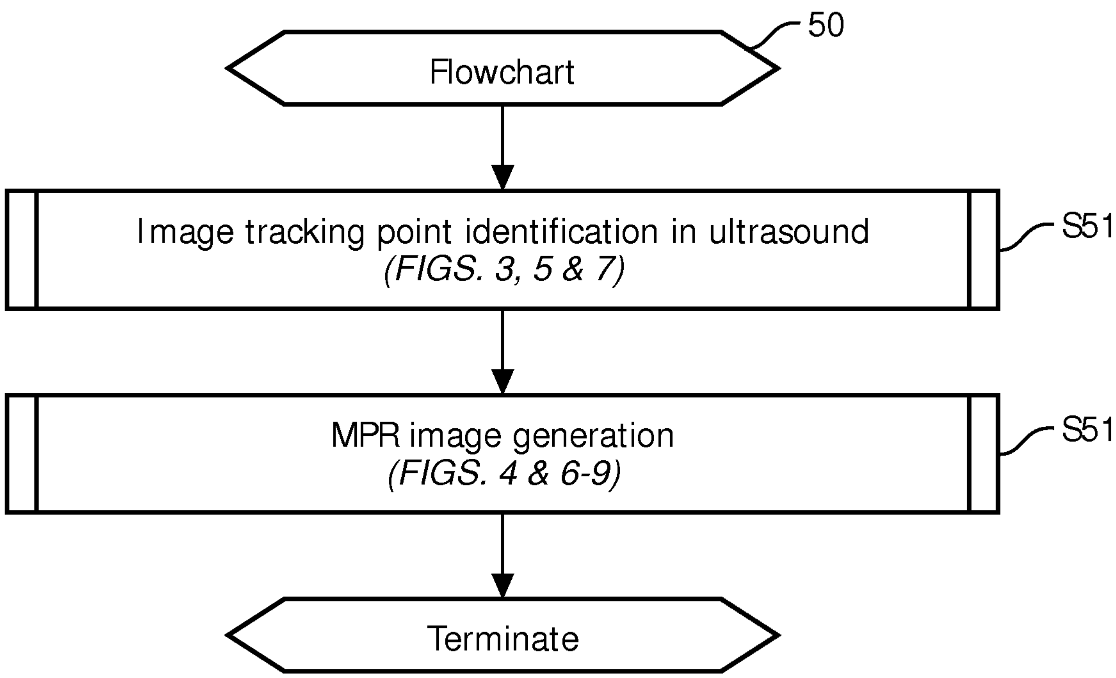
50
Flowchart
Image tracking point identification in ultrasound
(FIGS. 3, 5 & 7)
S51
MPR image generation
(FIGS. 4 & 6-9)
S51
Terminate

FIG. 2

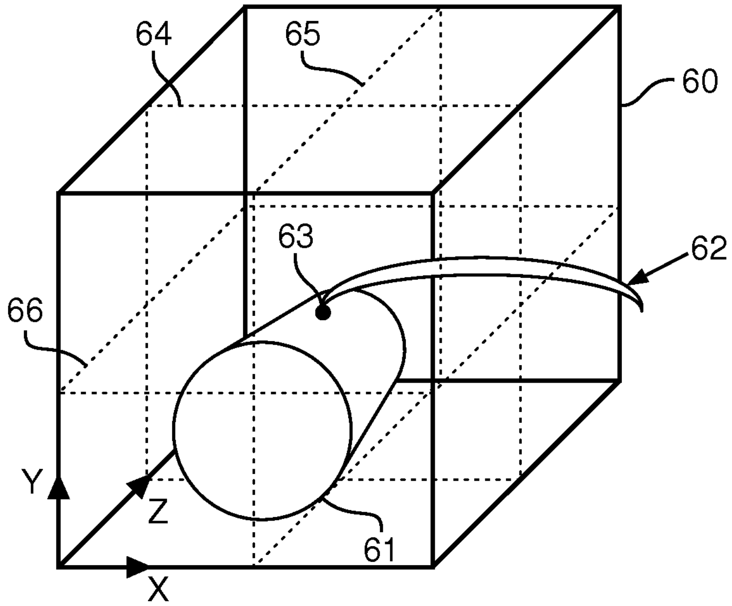

FIG. 3

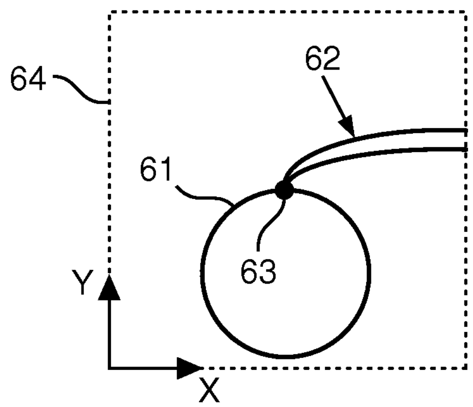

FIG. 4A

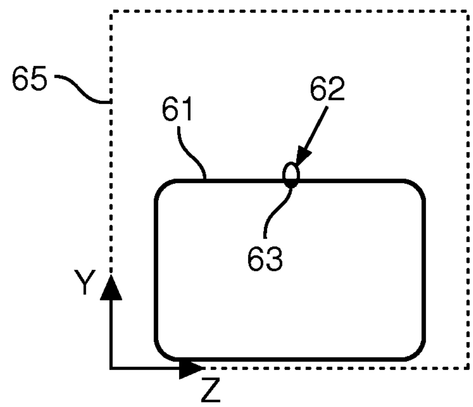

FIG. 4B

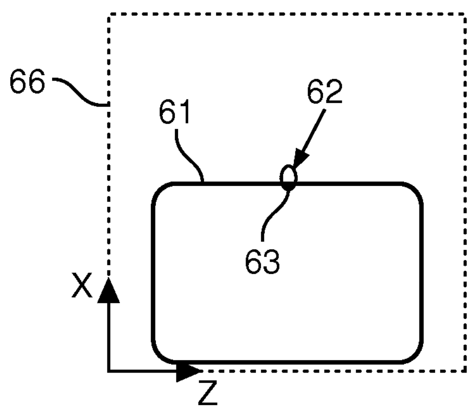

FIG. 4C

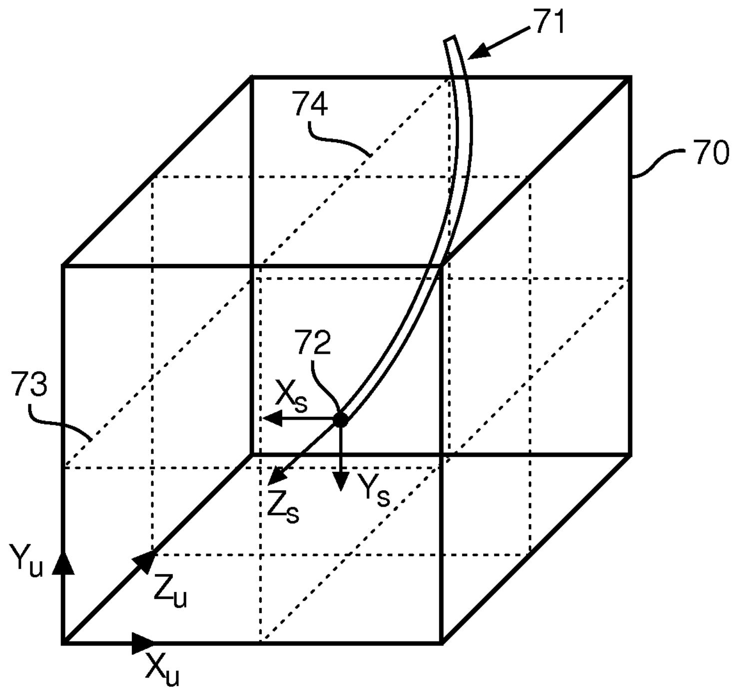

FIG. 5

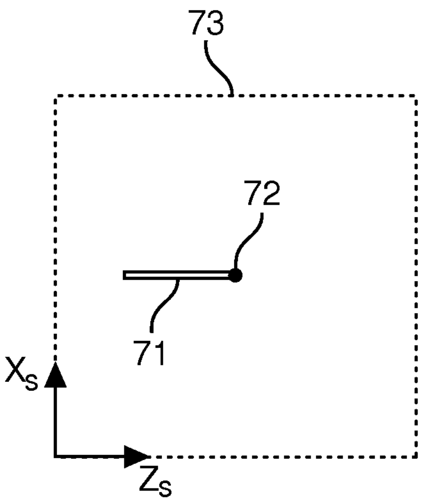

FIG. 6A

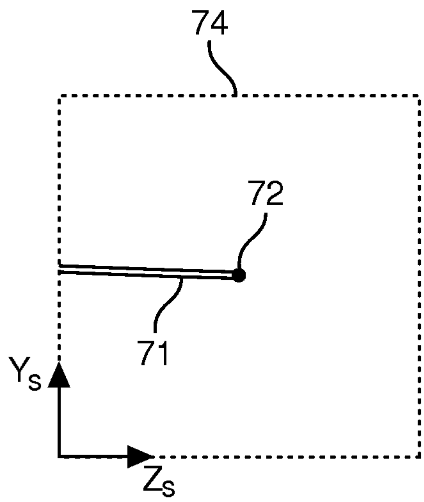

FIG. 6B

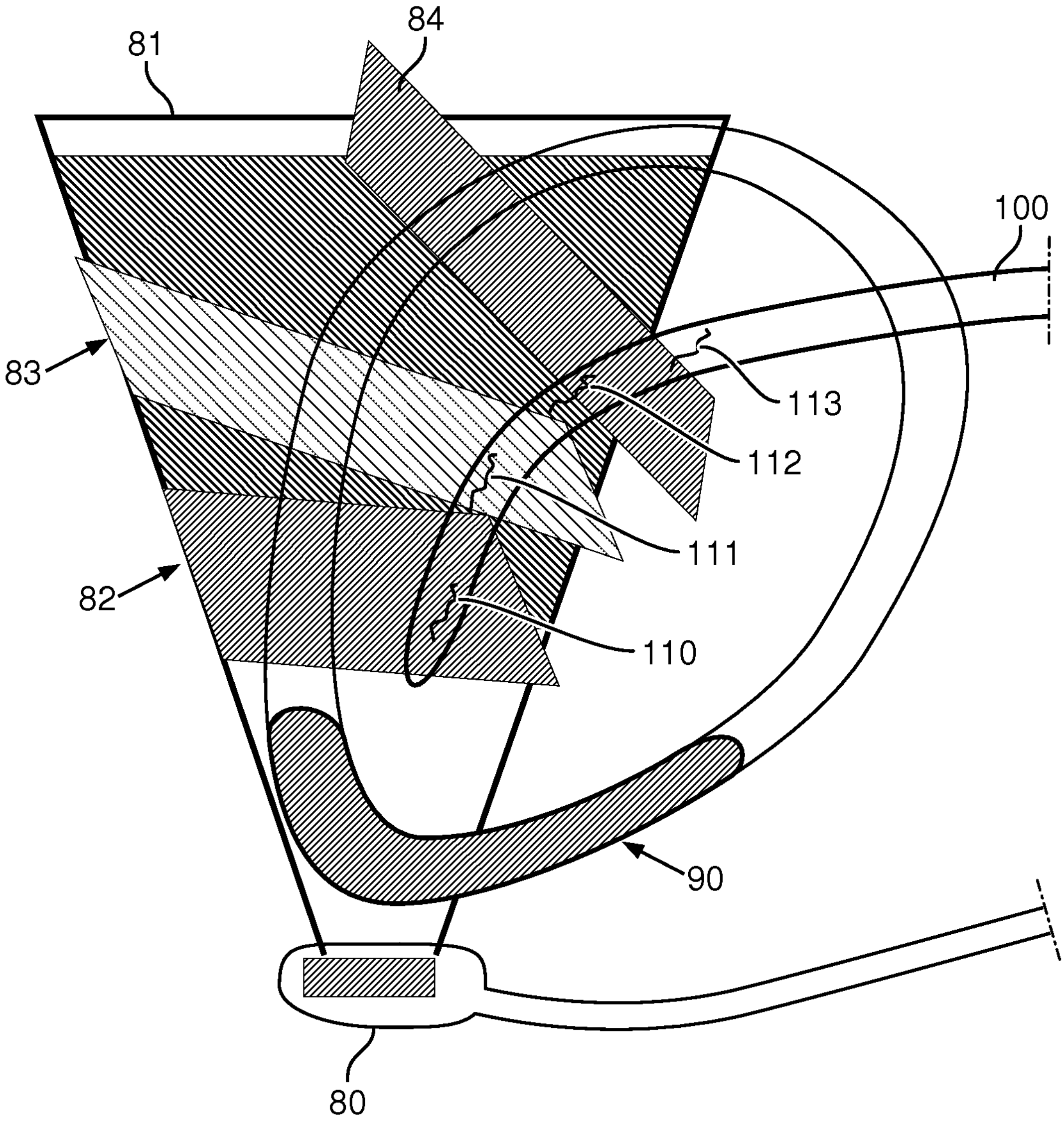

FIG. 7

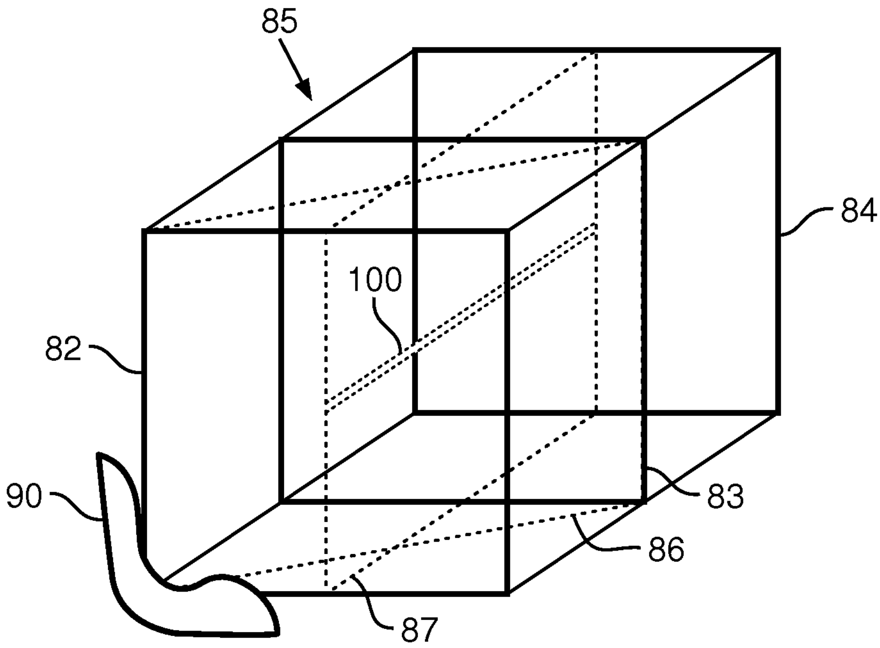

FIG. 8

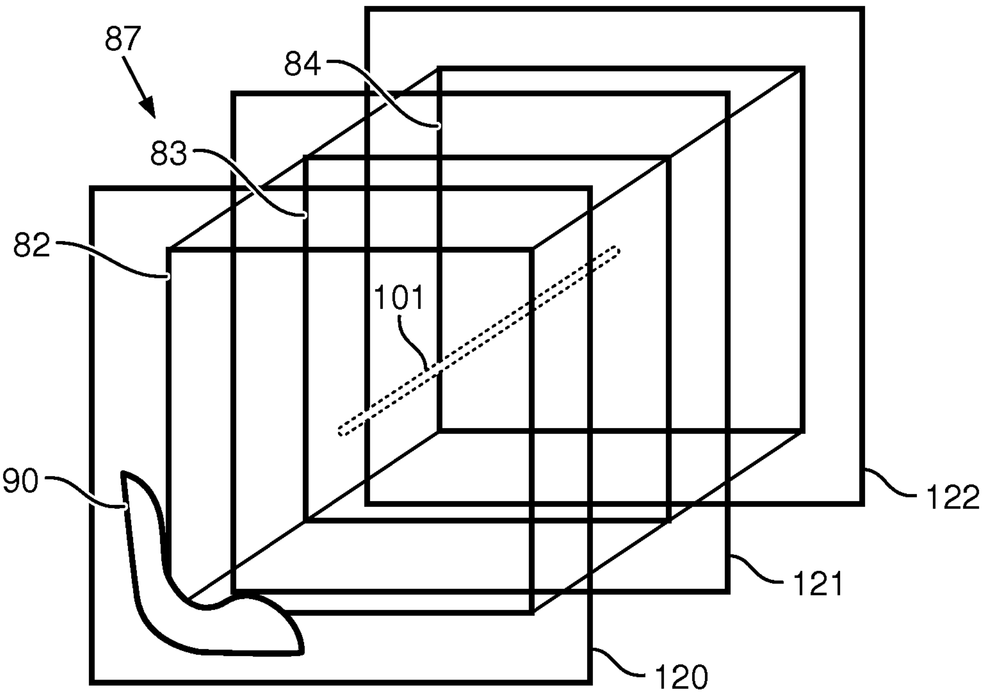

FIG. 9

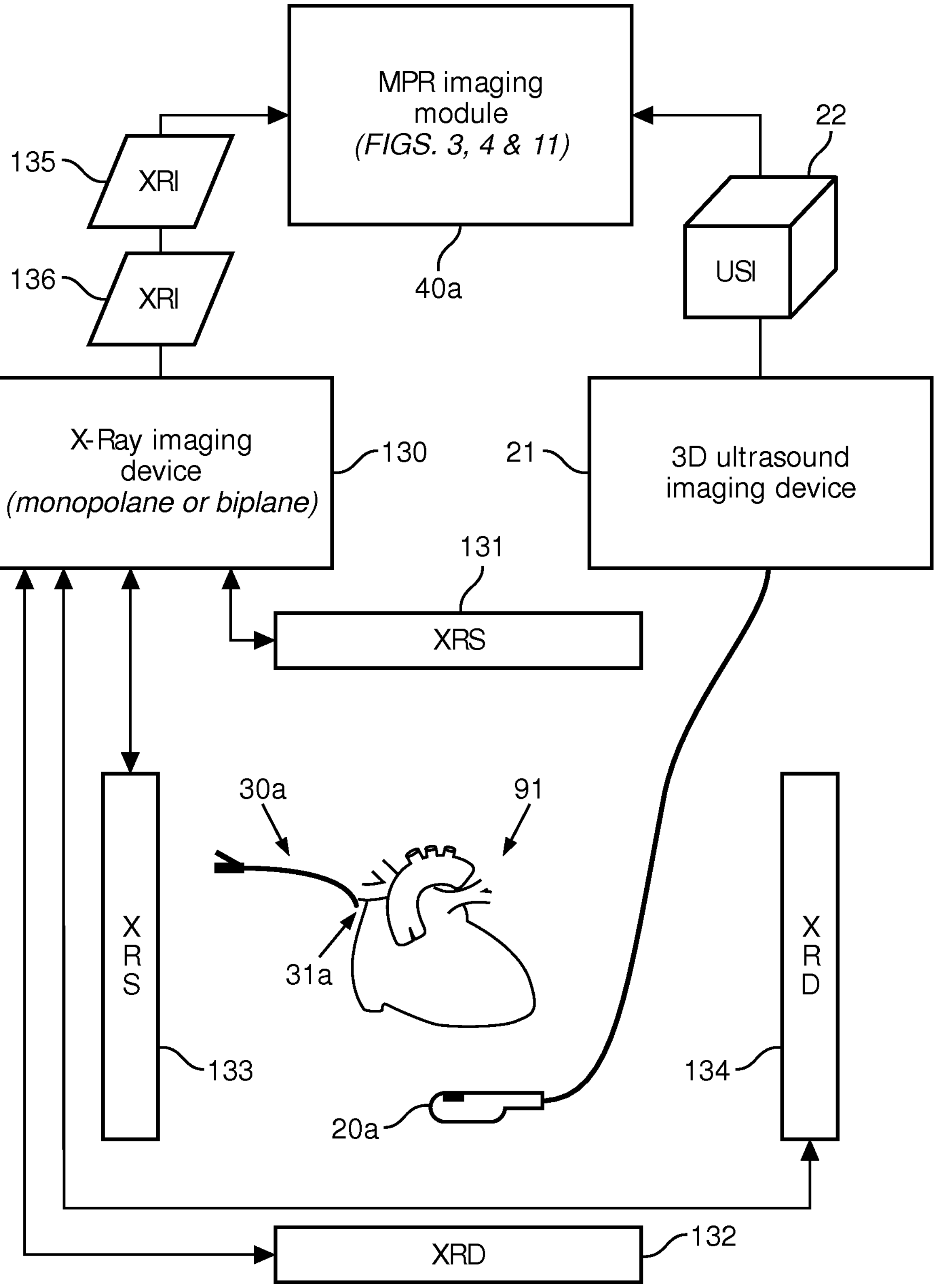
MPR imaging module (FIGS. 3, 4 & 11)
40a
22
USI
135
XRI
136
XRI
X-Ray imaging device (monopolane or biplane)
130
21
3D ultrasound imaging device
131
XRS
30a
91
XRS
31a
133
XRD
134
20a
XRD
132

FIG. 10

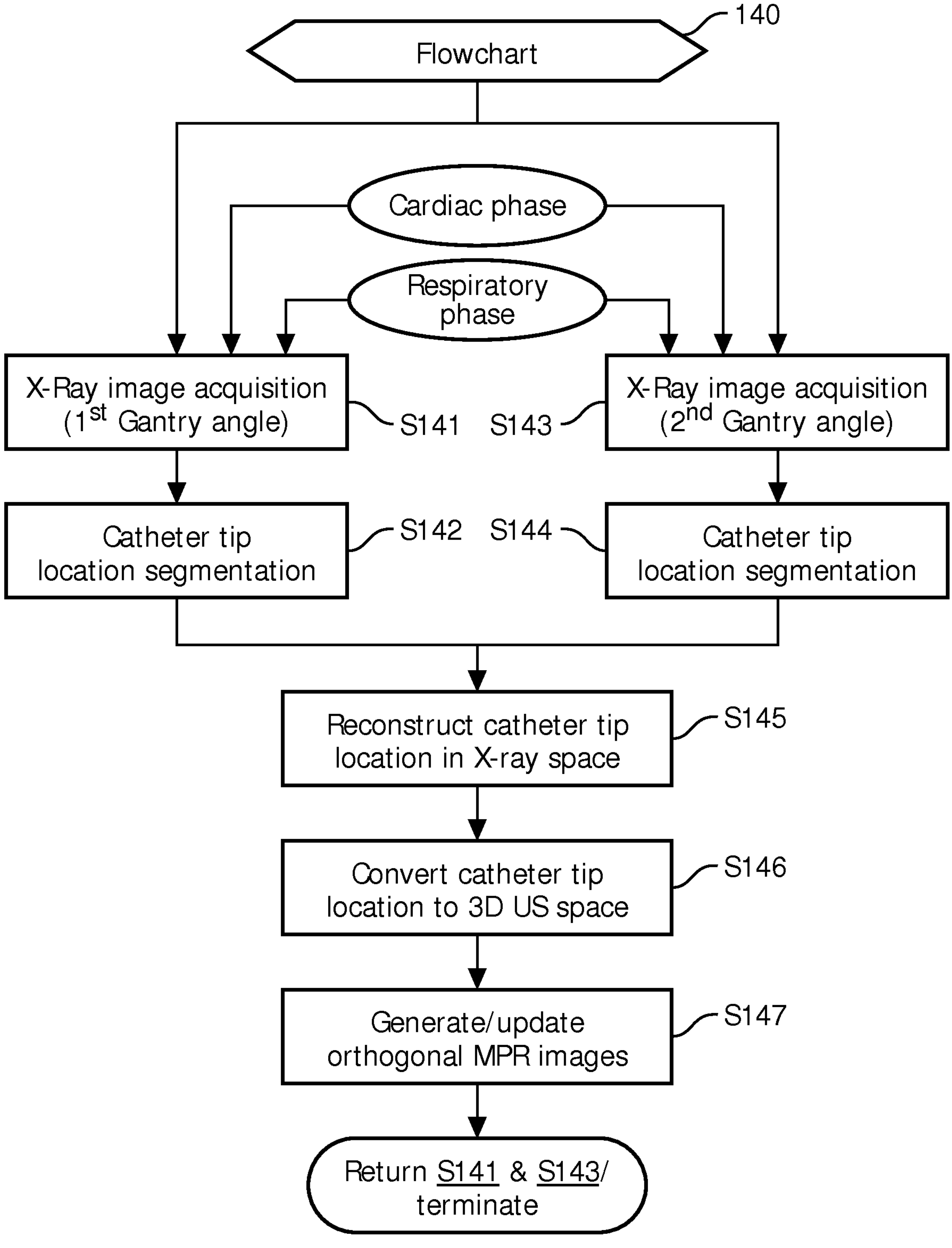
140
Flowchart
Cardiac phase
Respiratory phase
X-Ray image acquisition (1st Gantry angle)
S141
S143
X-Ray image acquisition (2nd Gantry angle)
Catheter tip location segmentation
S142
S144
Catheter tip location segmentation
Reconstruct catheter tip location in X-ray space
S145
Convert catheter tip location to 3D US space
S146
Generate/update orthogonal MPR images
S147
Return S141 & S143/ terminate

FIG. 11

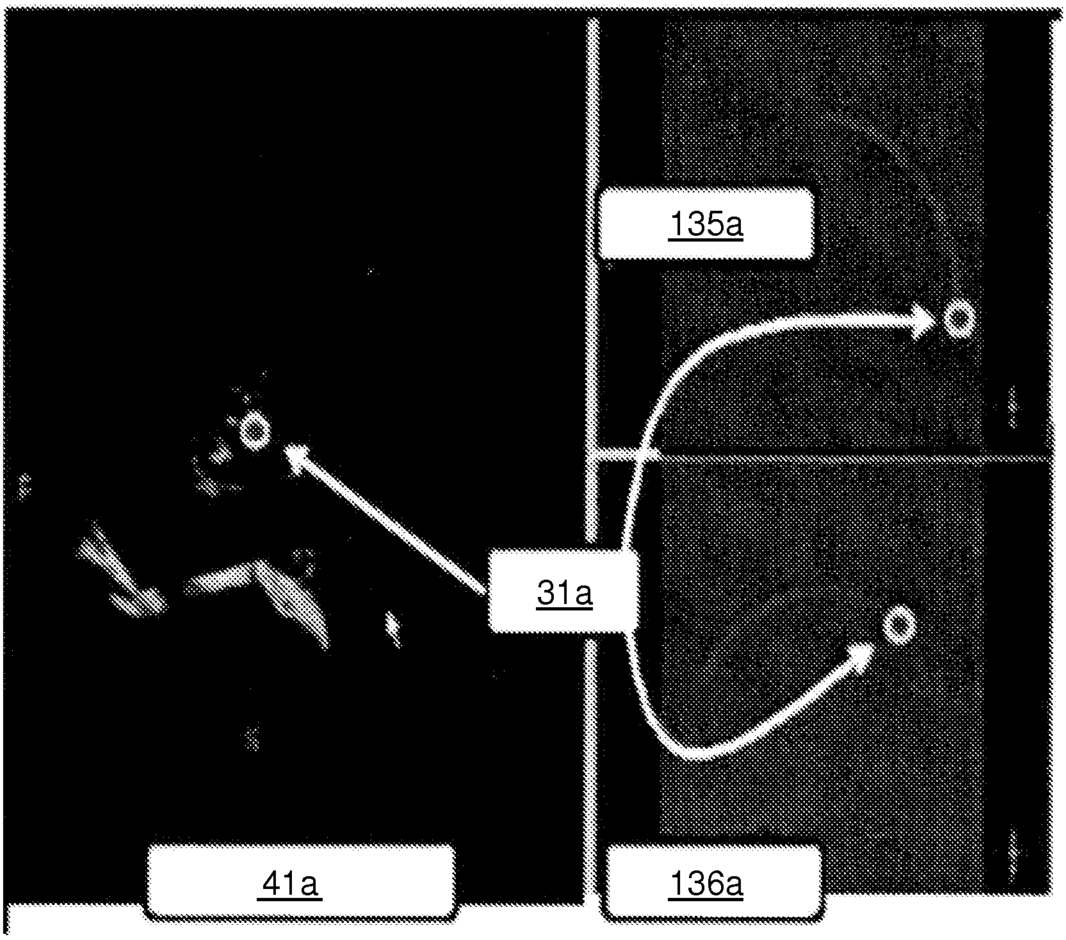

FIG. 12

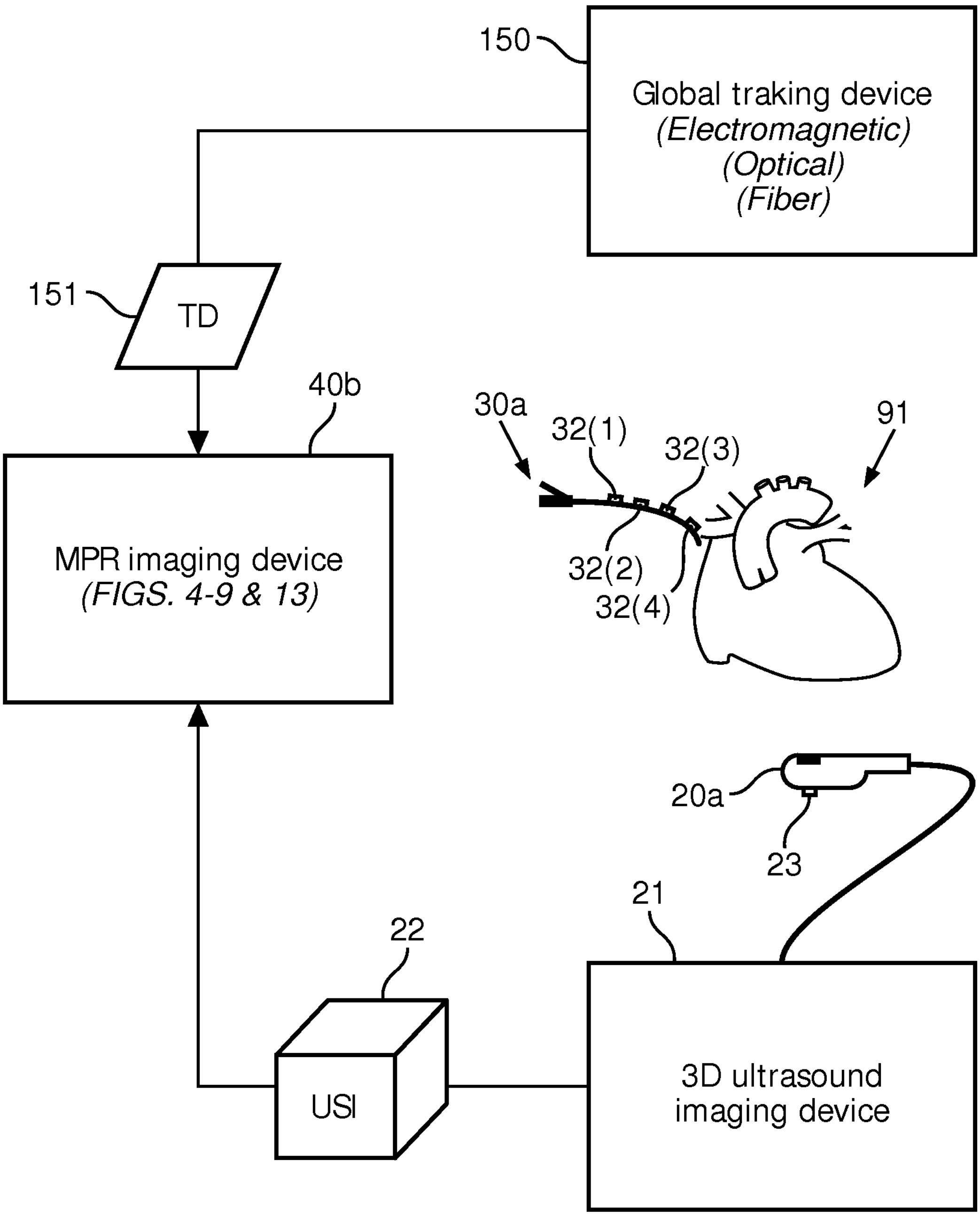
150
Global traking device
(Electromagnetic)
(Optical)
(Fiber)
151
TD
40b
MPR imaging device
(FIGS. 4-9 & 13)
30a
32(1)
32(3)
91
32(2)
32(4)
20a
23
21
22
USI
3D ultrasound
imaging device

FIG. 13

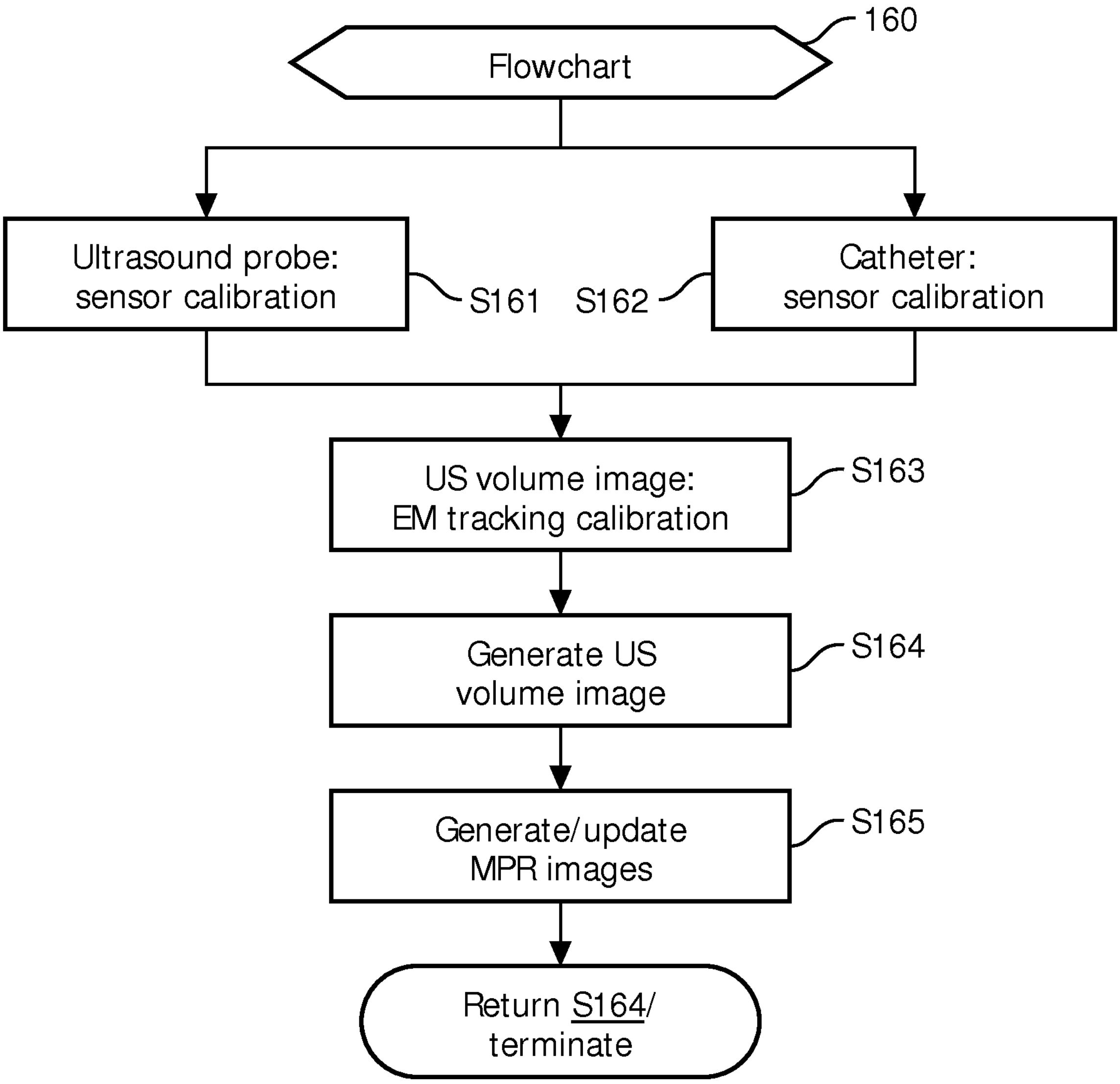
160
Flowchart
Ultrasound probe:
sensor calibration
S161
S162
Catheter:
sensor calibration
US volume image:
EM tracking calibration
S163
Generate US
volume image
S164
Generate/update
MPR images
S165
Return S164/
terminate

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2008221446 A **[0006]**

专利名称(译)	Mpr切片选择用于三维超声中导管的可视化		
公开(公告)号	EP2699166B1	公开(公告)日	2019-09-04
申请号	EP2012723529	申请日	2012-04-19
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	PARTHASARATHY VIJAY JAIN AMEET KUMAR HATT III CHARLES RAY RAVAL AMISH N		
发明人	PARTHASARATHY, VIJAY JAIN, AMEET KUMAR HATT (III), CHARLES RAY RAVAL, AMISH, N.		
IPC分类号	A61B8/08		
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代理机构(译)	STEFFEN , THOMAS		
优先权	61/477659 2011-04-21 US		
其他公开文献	EP2699166A2		
外部链接	Espacenet		

摘要(译)

系统采用介入工具（30），超声成像系统和多平面重新格式化模块（40）。介入工具（30）具有一个或多个图像跟踪点（31）。超声成像系统包括超声探头（20），其可操作用于在解剖区域内生成介入工具（30）的一部分或全部的超声体积图像（22）。多平面重新格式化成像模块（40）在解剖区域内生成介入工具（30）的两个或更多个多平面重新格式化图像（41）。一代两个多平面重新格式化图像（41）包括超声体积图像（22）内的每个图像跟踪点（31）的识别，以及每个识别的图像跟踪点（31）的利用作为多平面重新格式化图像（41）。

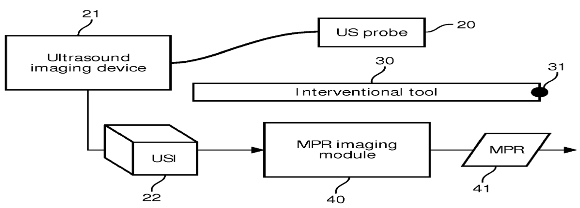

FIG. 1

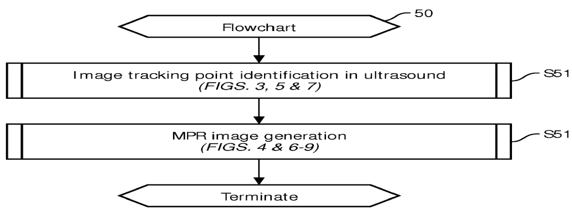

FIG. 2