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(54) SYSTEM AND METHOD FOR AUTOMATICALLY OBTAINING ULTRASOUND IMAGE PLANES BASED ON PATIENT SPECIFIC INFORMATION

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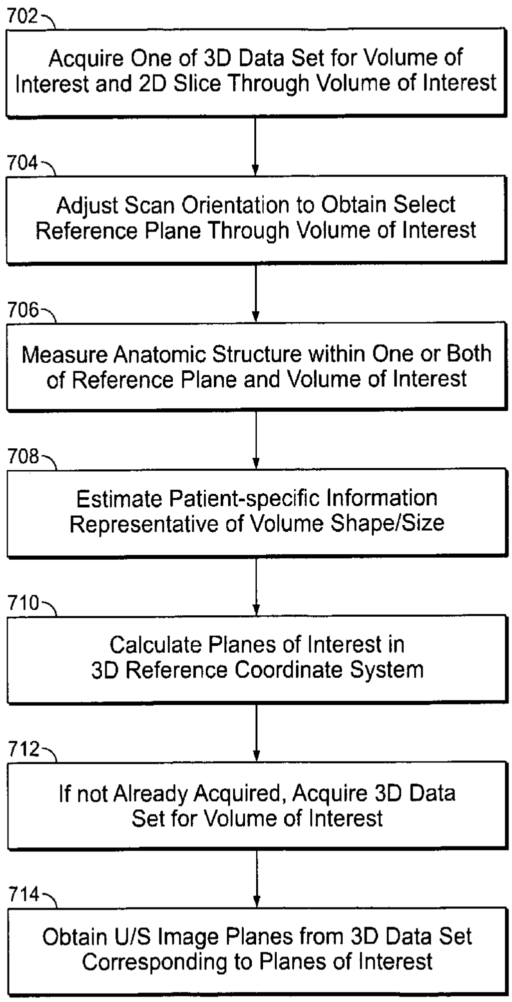
(57) **ABSTRACT**

A diagnostic ultrasound system is provided for automatically displaying multiple planes from a volume of interest. The system comprises a transducer for acquiring ultrasound data associated with a volume of interest having a target object therein. They system further comprises a user interface for designating a reference plane within the volume on interest. A processor module receives patient specific information representative of at least one of a shape and size of the target object and maps the reference plane and the ultrasound data into a 3D reference coordinate system. The processor module automatically calculates at least one plane of interest within the 3D reference coordinate system based on the reference plane and the patient specific information.



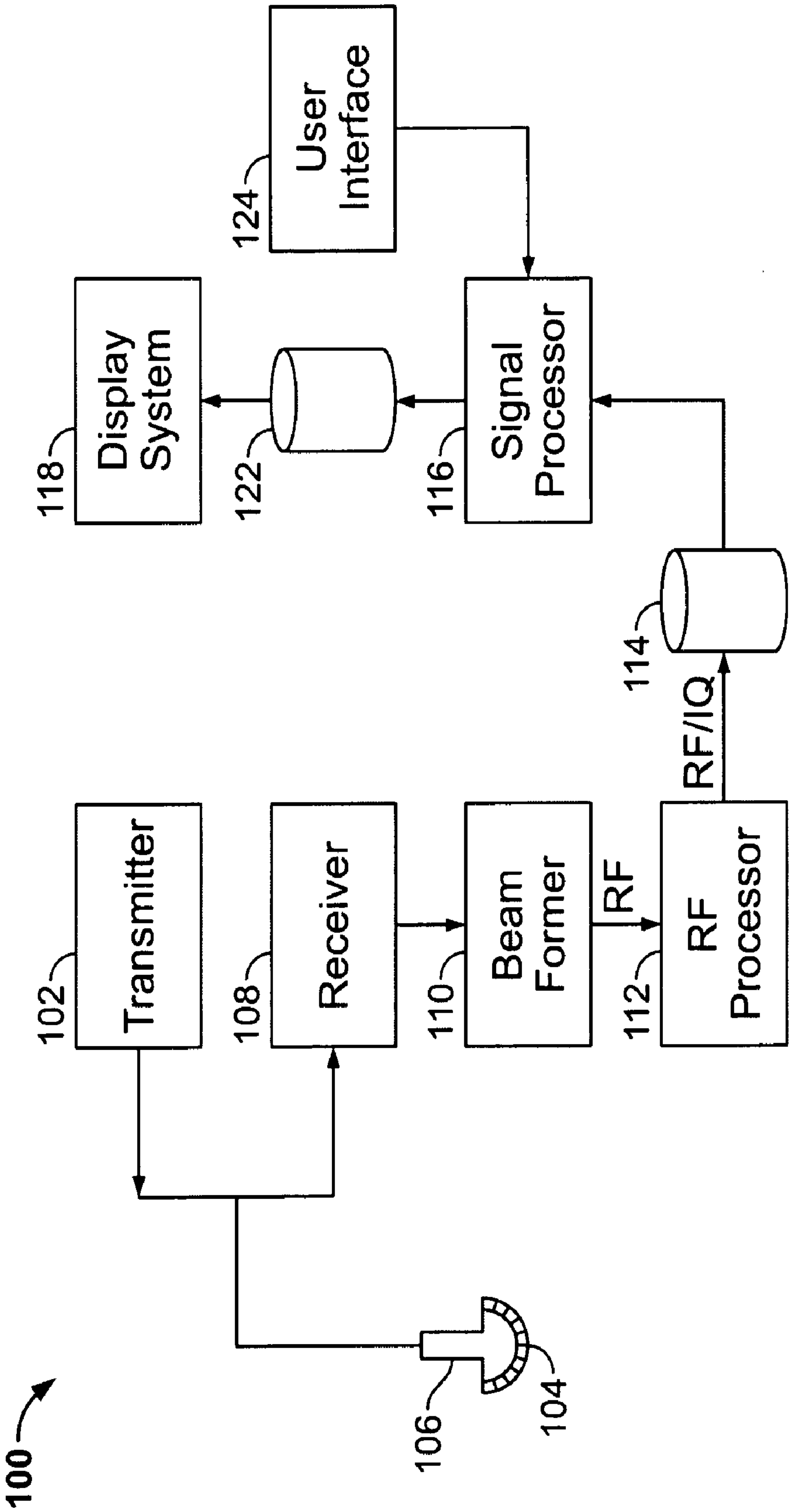

100
102
Transmitter
108
Receiver
110
Beam Former
RF
112
RF Processor
RF/IQ
114
116
Signal Processor
122
118
Display System
124
User Interface
106
104

FIG. 1

Patient-specific Information (202)	Auto-image Plane of Interest (204)	Translation Coordinates (206)	Rotation Coordinates (208)
Fetus — Wk 15	Plane 304	X1, Y1, Z1	A1, B1, C1
Fetus — Wk 17	Plane 305	X2, Y2, Z2	A2, B2, C2
⋮	Plane 306	X3, Y3, Z3	A3, B3, C3
Fetus — Wk 20	Plane 404	X4, Y4, Z4	A4, B4, C4
	Plane 405	X5, Y5, Z5	A5, B5, C5
Fetus — Wk 22	Plane 406	X6, Y6, Z6	A6, B6, C6
	Plane 407	X7, Y7, Z7	A7, B7, C7

FIG. 2

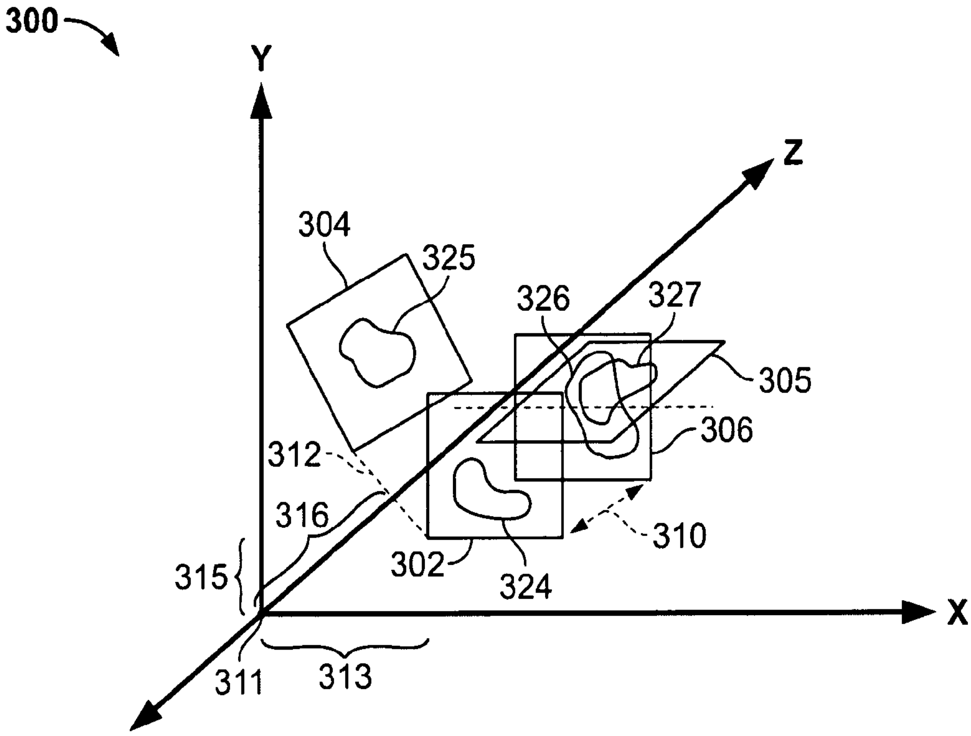

300
Y
Z
X
304
325
326
327
305
306
312
316
310
315
302
324
311
313

FIG. 3

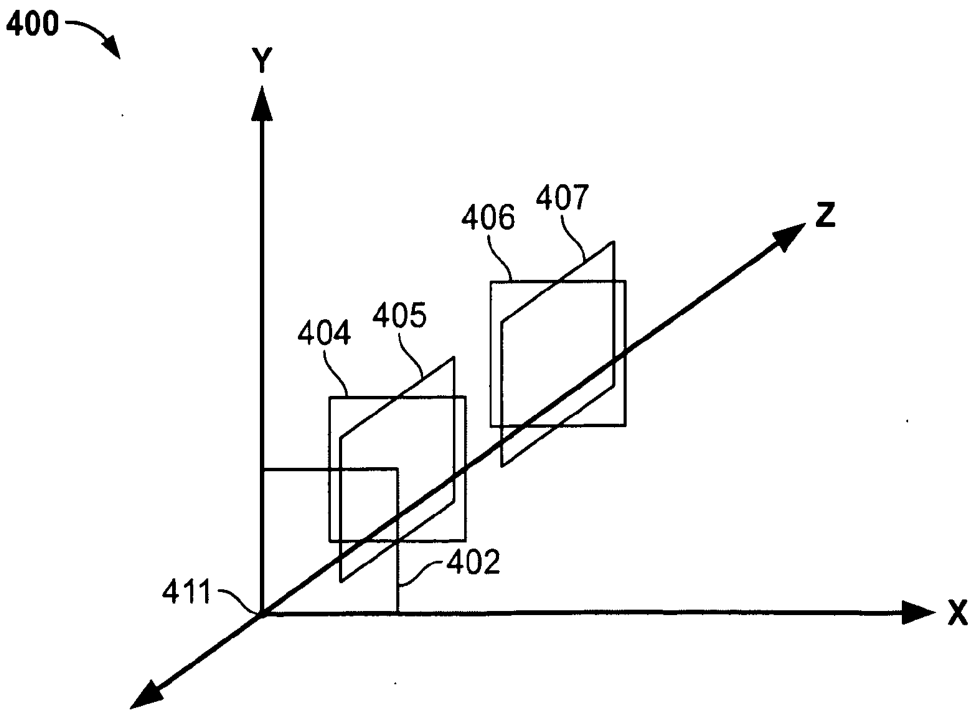

400
Y
Z
X
406
407
404
405
402
411

FIG. 4

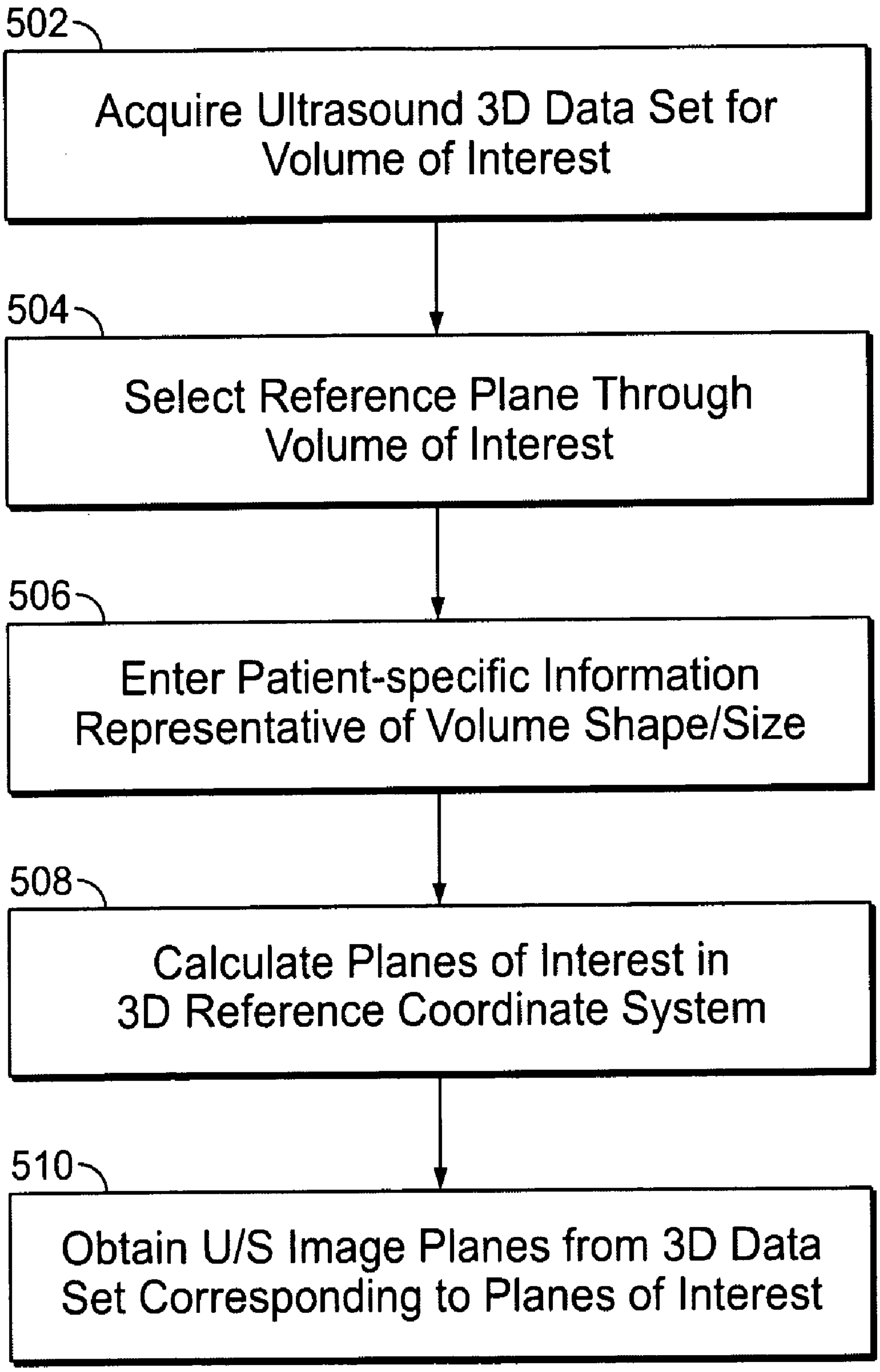

502
Acquire Ultrasound 3D Data Set for Volume of Interest
504
Select Reference Plane Through Volume of Interest
506
Enter Patient-specific Information Representative of Volume Shape/Size
508
Calculate Planes of Interest in 3D Reference Coordinate System
510
Obtain U/S Image Planes from 3D Data Set Corresponding to Planes of Interest

FIG. 5

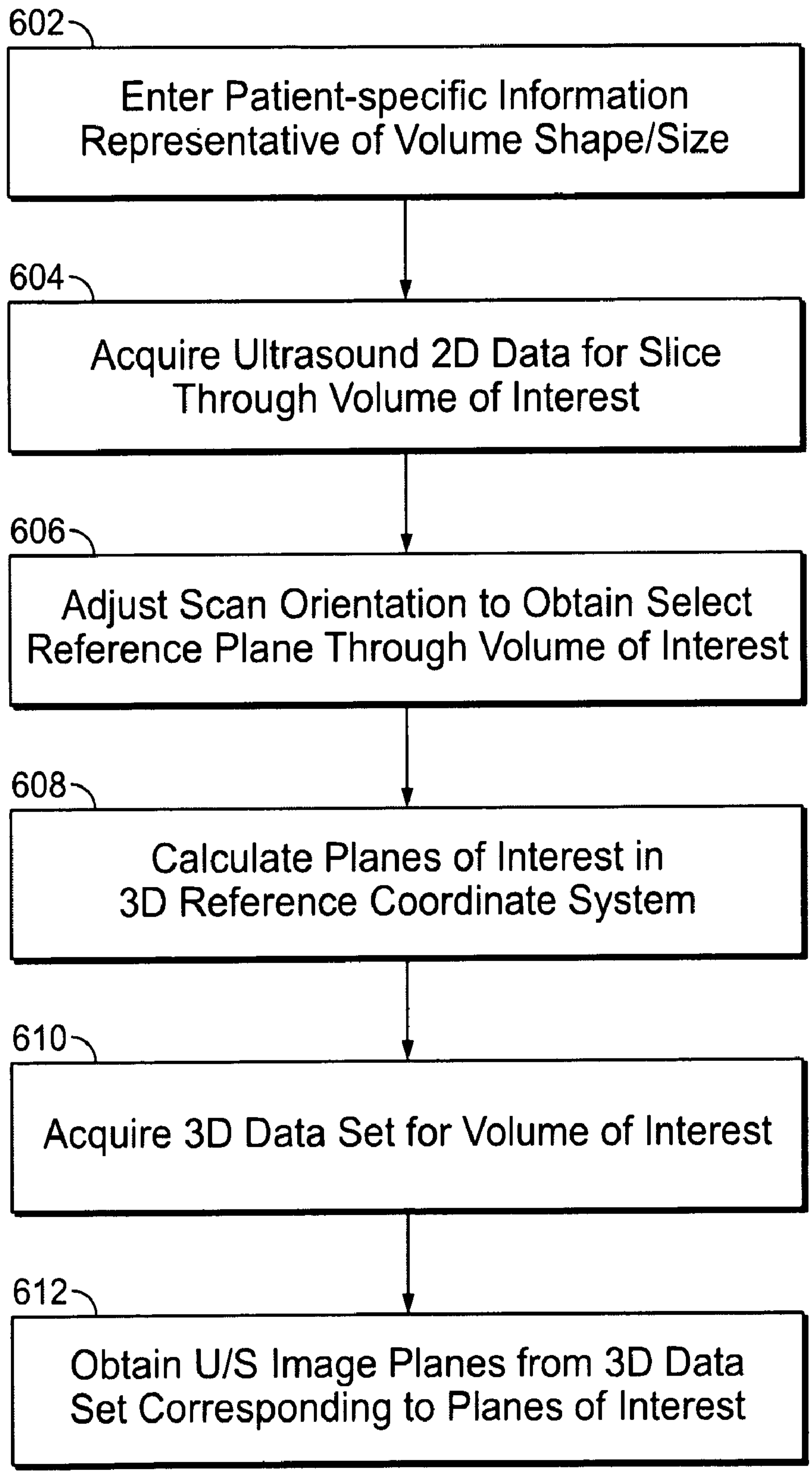

602
Enter Patient-specific Information Representative of Volume Shape/Size
604
Acquire Ultrasound 2D Data for Slice Through Volume of Interest
606
Adjust Scan Orientation to Obtain Select Reference Plane Through Volume of Interest
608
Calculate Planes of Interest in 3D Reference Coordinate System
610
Acquire 3D Data Set for Volume of Interest
612
Obtain U/S Image Planes from 3D Data Set Corresponding to Planes of Interest

FIG. 6

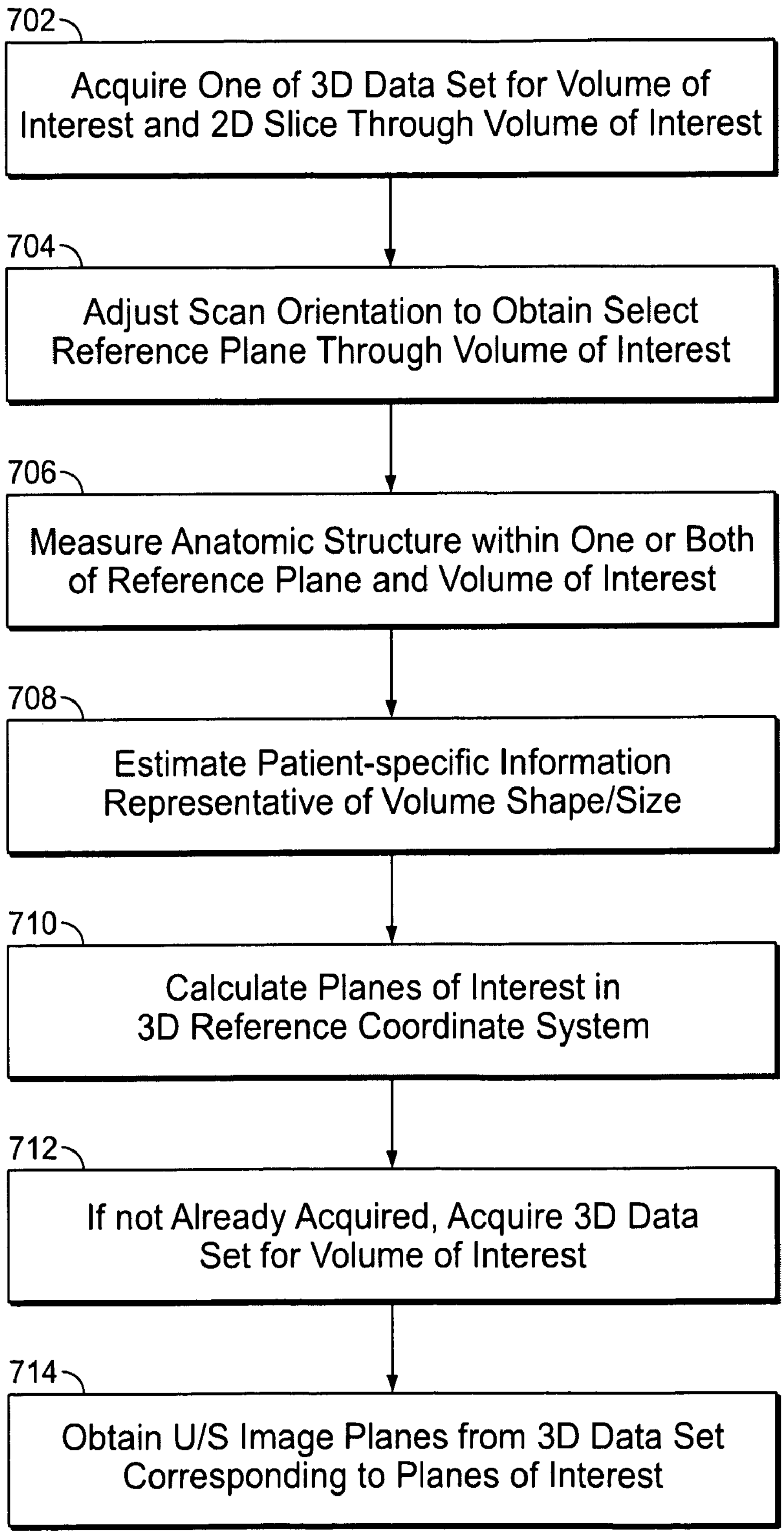

702
Acquire One of 3D Data Set for Volume of Interest and 2D Slice Through Volume of Interest
704
Adjust Scan Orientation to Obtain Select Reference Plane Through Volume of Interest
706
Measure Anatomic Structure within One or Both of Reference Plane and Volume of Interest
708
Estimate Patient-specific Information Representative of Volume Shape/Size
710
Calculate Planes of Interest in 3D Reference Coordinate System
712
If not Already Acquired, Acquire 3D Data Set for Volume of Interest
714
Obtain U/S Image Planes from 3D Data Set Corresponding to Planes of Interest

FIG. 7

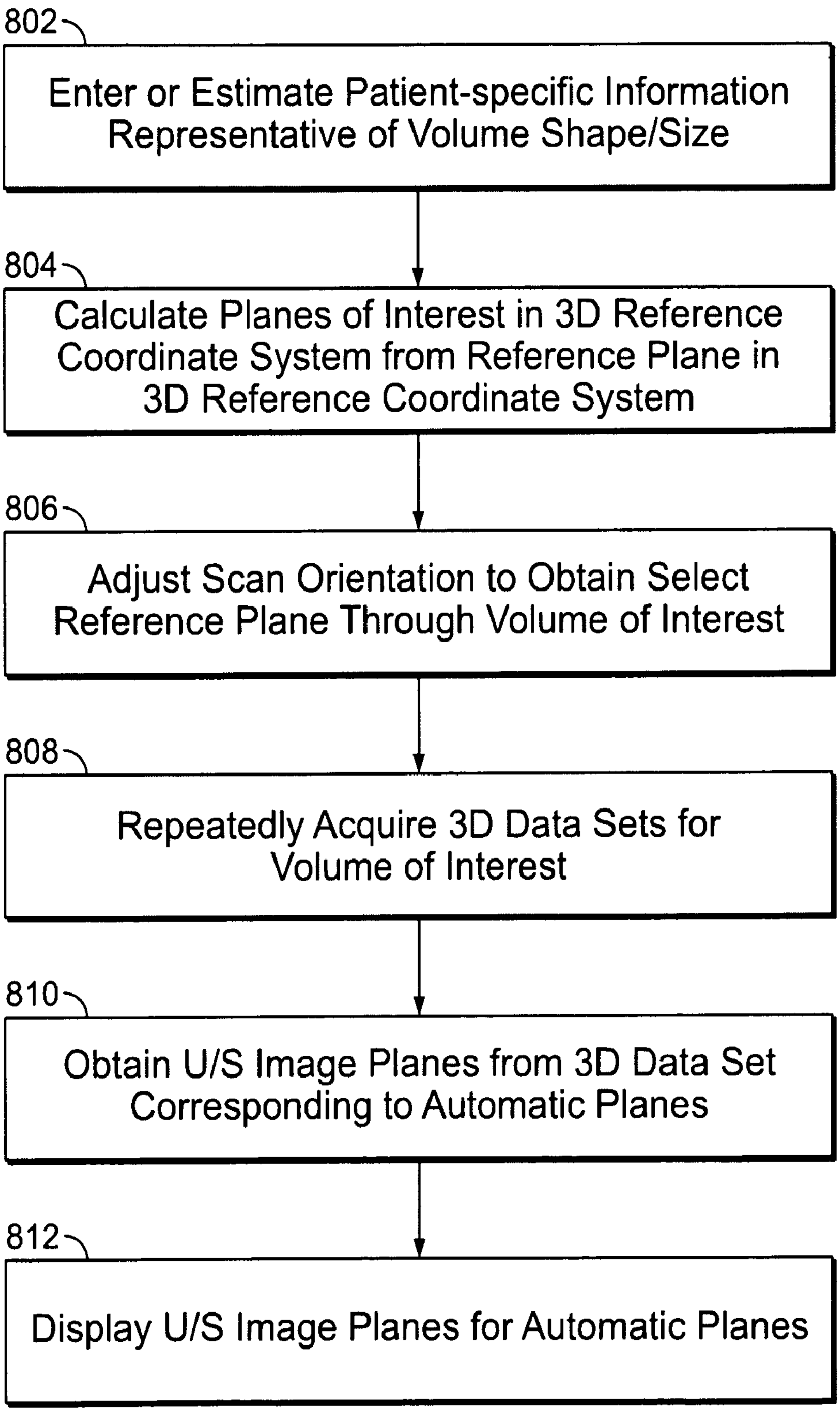

802
Enter or Estimate Patient-specific Information Representative of Volume Shape/Size
804
Calculate Planes of Interest in 3D Reference Coordinate System from Reference Plane in 3D Reference Coordinate System
806
Adjust Scan Orientation to Obtain Select Reference Plane Through Volume of Interest
808
Repeatedly Acquire 3D Data Sets for Volume of Interest
810
Obtain U/S Image Planes from 3D Data Set Corresponding to Automatic Planes
812
Display U/S Image Planes for Automatic Planes

FIG. 8

SYSTEM AND METHOD FOR AUTOMATICALLY OBTAINING ULTRASOUND IMAGE PLANES BASED ON PATIENT SPECIFIC INFORMATION

RELATED APPLICATION

[0001] The present application relates to and claims priority from Provisional Application Ser. No. 60/793,908 filed Apr. 20, 2006 titled "SYSTEM AND METHOD FOR AUTOMATICALLY OBTAINING ULTRSOUND IMAGE PLANES BASED ON PATIENT SPECIFIC INFORMATION", the complete subject matter of which is hereby expressly incorporated in its entirety.

BACKGROUND OF THE INVENTION

[0002] Embodiments of the present invention relate generally to systems and methods for automatically obtaining ultrasound image planes of the volume of interest, and more specifically for automatic image plane calculation based upon patient specific information.

[0003] Ultrasound systems are used in a variety of applications and a by a variety of individuals with varied levels of skill. In many examinations, operators of the ultrasound system review selected combinations of ultrasound images in accordance with predetermined protocols. In order to obtain the desired combination of ultrasound images, the operator steps through a sequence of operations to identify and capture one or more desired image planes. At least one ultrasound system has been proposed, generally referred to in as automated multiplanar imaging that seeks to standardize acquisition and display of the desired image planes. In accordance with this recently proposed ultrasound system, a volumetric image is acquired in a standardized manner and a reference plane is identified. Based upon the reference plane, multiple image planes are automatically obtained from an acquired volume of ultrasound information without detailed intervention by the user to select each of the multiple image planes.

[0004] However, conventional ultrasound systems have experience certain limitations. The conventional automated multiplanar imaging process progresses independent of, and without consideration for, characteristics of the target object that render the target object unique and size and shape. Consequently, when a reference plane is identified, the multiple images that are automatically calculated may not be properly positioned within or relative to the target object if the size and shape of the target object differ from the standard.

[0005] A need remains for an improved method and system that affords automated multiplanar imaging, while remaining adaptable to different types, shapes and sizes of objects.

BRIEF DESCRIPTION OF THE INVENTION

[0006] In accordance with an embodiment of the present invention, a diagnostic ultrasound system is provided for automatically displaying multiple planes from a volume of interest. The system comprises a transducer for acquiring ultrasound data associated with a volume of interest having a target object therein. They system further comprises a user interface for designating a reference plane within the volume on interest. A processor module receives patient specific information representative of at least one of a shape and size of the target object and maps the reference plane and the ultrasound data into a 3D reference coordinate system. The processor module automatically calculates at least one plane of interest within the 3D reference coordinate system based on the reference plane and the patient specific information.

[0007] For example, the volume of interest may constitute an organ of a fetus (e.g. the myocardium, the head, a limb, the liver, an organ and the like). The patient specific information may include geometric parameters (e.g. diameter, circumference, an organ type identifier in the like). Alternatively, or in addition, the patient specific information may include non-geometric parameters (e.g. age, weight, sex and the like). Optionally, the processor module may calculate a translation distance and a rotation distance from the reference plane to determine a position and orientation of the plane of interest within the 3D reference coordinate system, wherein the translation and rotation distances are based on an age of a patient.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates a block diagram of a diagnostic ultrasound system formed in accordance with an embodiment of the present invention.

[0009] FIG. **2** illustrates a table storing an association between patient specific information and automatic image planes to be generated in accordance with an embodiment of the present invention.

[0010] FIG. **3** represents a graphical representation of image planes that may be automatically calculated from a reference plane in accordance with an embodiment of the present invention.

[0011] FIG. **4** represents and other graphical representation of image planes that may be automatically calculated from a reference plane in accordance with an embodiment of the present invention.

[0012] FIG. **5** illustrates a processing sequence to obtain ultrasound image planes from a pre-acquired 3-D data set in accordance with an embodiment of the present invention.

[0013] FIG. **6** illustrates a processing sequence to obtain selected 2-D ultrasound image planes in accordance with an embodiment of the present invention.

[0014] FIG. **7** illustrates a processing sequence to obtain ultrasound image planes based upon measured anatomic structures in accordance with an embodiment of the present invention.

[0015] FIG. **8** illustrates a processing sequence to obtain ultrasound image planes a real-time continuously updated 3-D data set in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] FIG. **1** illustrates a block diagram of an ultrasound system **100** formed in accordance with an embodiment of the present invention. The ultrasound system **100** includes a transmitter **102** which drives an array of elements **104** within a transducer **106** to emit pulsed ultrasonic signals into a body. A variety of geometries may be used. The ultrasonic signals are back-scattered from structures in the body, like blood cells or muscular tissue, to produce echoes which return to the elements **104**. The echoes are received by a receiver **108**. The received echoes are passed through a beamformer **110**, which performs beamforming and outputs an RF signal. The RF signal then passes through an RF processor **112**. Alternatively, the RF processor **112** may include a complex demodulator (not shown) that demodulates the RF signal to form IQ data pairs representative of the echo signals. The RF or IQ signal data may then be routed directly to RF/IQ buffer **114** for temporary storage.

[0017] The ultrasound system **100** also includes a signal processor **116** to process the acquired ultrasound information (i.e., RF signal data or IQ data pairs) and prepare frames of ultrasound information for display on display system **118**. The signal processor **116** is adapted to perform one or more processing operations according to a plurality of selectable ultrasound modalities on the acquired ultrasound information. Acquired ultrasound information may be processed in real-time during a scanning session as the echo signals are received. Additionally or alternatively, the ultrasound information may be stored temporarily in RF/IQ buffer **114** during a scanning session and processed in less than real-time in a live or off-line operation. An image buffer **122** is included for storing processed frames of acquired ultrasound information that are not scheduled to be displayed immediately. The image buffer **122** may comprise any known data storage medium.

[0018] The signal processor **116** is connected to a user interface **124** that controls operation of the signal processor **116** as explained below in more detail. The display system **118** includes one or more monitors that present patient information, including diagnostic ultrasound images to the user for diagnosis and analysis.

[0019] The system **100** obtains volumetric data sets by various techniques (e.g., 3D scanning, real-time 3D imaging, volume scanning, 2D scanning with transducers having positioning sensors, freehand scanning using a Voxel correlation technique, 2D or matrix array transducers and the like). The transducer **106** is moved, such as along a linear or arcuate path, while scanning a region of interest (ROI). At each linear or arcuate position, the transducer **106** obtains scan planes that are stored in the memory **114**.

[0020] FIG. **2** illustrates a table **200** that stores the relation between patient specific information **202** and predetermined automatic image planes of interest **204**. Each plane of interest **204** is associated in the table **200** with a series of translation and rotation coordinates **206** and **208**, respectively. In the example of FIG. **2**, the three-dimensional reference coordinate system is in Cartesian coordinates (e.g. XYZ). Thus, the translation coordinates **206** represent translation distances along the X, Y and Z axes. The rotation coordinates **208** represent rotation distances about the X, Y and Z axes. The translation and rotation coordinates **206**, **208** extend from a reference plane.

[0021] FIG. **3** represents a graphical representation of image planes that may be automatically calculated from a reference plane in accordance with an embodiment of the present invention. FIG. **3** illustrates a three-dimensional reference coordinate system **300**, in which a reference plane **302** has been designated. The reference plane **302** may be acquired as a single two-dimensional image (e.g. B-mode image or otherwise). Alternatively, the reference plane **302** may be acquired as part of a three-dimensional scan of a volume of interest. For example, the reference plane may constitute a four chamber view of a fetal heart, the right ventricular outflow, the left ventricular outflow, the ductal arch, the aortic arch, venous connections, and the three vessel view. Once the reference plane **302** is adjusted and reoriented until the reference plane **302** contains a reference anatomy **324**. Once the reference plane **302** is acquired, it is mapped into the 3-D reference coordinate system **300**. In the example of FIG. **3**, the reference plane **302** is located distances **313-316** from the origin **311** of the 3-D reference coordinate system **300** along the X, Y, and Z axes.

[0022] After acquiring the reference plane **302** and the fetal age, the processor module **116** automatically calculates additional image planes of interest based upon patient specific information, such as the age of a fetus. The patient specific information may constitute a geometric parameter, and nongeometric parameter or a combination thereof. The patient specific information may provide one-dimensional, two-dimensional or three-dimensional information regarding the target organ. Examples of geometric parameters are an identification of a type of organ, a diameter, a circumference, a length, an organ dimension and the like. The type of organ may be the heart, head, liver, arm, leg or other organ. Examples of non-geometric parameters are age, weight, sex and the like. For example, when examining a fetus that is in week 15 of gestation, a fetal organ or area of interest may be positioned, relative to the reference anatomy **324**, at a position denoted by image **325**. Once the processor module **116** receives the fetal age, processor module accesses the table **200** to obtain the translation coordinates X**1**, Y**1**, and Z**1** and the rotation coordinates A**1**, B**1**, and C**1**. The position and orientation of the image plane **304** is determined from the translation and rotation coordinates.

[0023] Alternatively, when the fetus is in week 17, a fetal organ or area of interest may be positioned, relative to the reference anatomy **324**, at a position denoted by images **326** and **327**. After acquiring the reference plane **302** and the fetal age, the processor module **116** automatically calculates the positions and orientations of image planes **305** and **306**. The image planes **305-306** of interest are located within the 3-D reference coordinate system **300**, but are translated and rotated from the position of the reference plane **302** by predetermined distances.

[0024] Thus, the positions of each image plane **304-306** is defined relative to the reference plane **302** based upon the fetal age. For example, image plane **306** is translated in the Z direction by a distance **310** from the reference plane **302**, while the image plane **304** is rotated about the Z axis by a predetermined arc in degrees **312**. The image plane **305** is both translated and rotated about multiple axes from the reference plane **302**.

[0025] FIG. **4** represents another graphical representation of image planes that may be automatically calculated from a reference plane in accordance with an embodiment of the present invention. In FIG. **4**, a three-dimensional reference coordinate system **400** is illustrated in Cartesian coordinates. Optionally, the coordinate reference system may be defined in polar accordance. Optionally, the reference plane **402** may be mapped to the origin **411** of the reference coordinate system **400**. In the example of FIG. **4**, image planes **404** and

405 are automatically calculated based upon the reference plane 402 when the fetus is 20 weeks old, while image planes 406-407 are automatically calculated based upon the reference plane 402 when the fetus is 22 weeks old. The image planes 406-407 are spaced further from the reference plane 402, along the Z direction, to account for the increased length of the organ of interest.

[0026] FIG. 5 illustrates a processing sequence to obtain ultrasound image planes from a pre-acquired 3-D data set in accordance with an embodiment of the present invention. Beginning at 502, a 3-D data set of ultrasound data is acquired for a volume of interest. At 504, the user selects a reference plane from the volume of interest. Once the user selects the reference plane, the reference plane may be mapped into a three-dimensional reference coordinate system. At 506, patient specific information is entered that represents the shape and/or size of the organ of interest within the volume of interest. For example, the patient specific information may be manually entered by the user (e.g. entering the age of a fetus). Alternatively, the patient specific information may be automatically calculated from other anatomic characteristics or structures within the reference plane. As a further option, the patient specific information may be obtained by accessing medical records previously saved and updated for the patient under examination. For example, the age of a fetus may be automatically calculated based upon the social security number or other unique ID of the patient by accessing the patient's medical records previously entered and updated in accordance with a pregnancy.

[0027] At 508, one or more image planes of interest are calculated within the three-dimensional reference coordinate system. At 510, ultrasound images, associated with the automatically calculated image planes, are obtained from the 3-D data set and presented as ultrasound images to a user in a desired format.

[0028] FIG. 6 illustrates a processing sequence to obtain select 2-D ultrasound image planes in accordance with an embodiment of the present invention. At 602, patient specific information is entered that represents the shape or size of the organ of interest within the volume of interest. At 604, a two-dimensional ultrasound slice or scan is acquired from within a volume of interest. At 604, the system need not yet perform a complete three-dimensional volumetric scan. Instead, at 604, a single slice or planar scan may be acquired. At 606, the user is afforded the ability to adjust the orientation and position of the probe in order to acquire a desired reference plane through a volume of interest. At 608, one or more image planes are calculated within a 3-D reference coordinate system based upon the select reference plane and the patient specific information. At 610, one or more select two-dimensional image planes are acquired from within the volume of interest. The acquired select 2-D image planes correspond to the image planes of interest calculated at 608. Optionally, the entire volume of interest need not be scanned, but instead the system need only acquire ultrasound information for the select 2-D image planes of interest. At 612, ultrasound images are displayed for the image planes of interest.

[0029] Optionally, any embodiment of FIG. 6, the ultrasound images associated with the select image planes may be continuously updated in real-time at a frame rate sufficiently high, relative to a fetal heart rate, to provide meaningful motion information.

[0030] FIG. 7 illustrates a processing sequence to obtain ultrasound image planes based upon measured anatomic structures in accordance with an embodiment of the present invention. Beginning at seven are two, the system acquires one of a 3-D data set for the volume of interest or one or more two-dimensional slices through the volume of interest. At 704, the user adjusts the scan orientation to obtain a select reference plane through the volume of interest. At 706, a measurement is obtained for an anatomic structure within one or both of the reference planes and the volume of interest. For example, the anatomic structure may represent a select bone within a fetus. By measuring the length of the select bone, the fetal age may be automatically determined.

[0031] At 708, the patient specific information is estimated representative of the shape or size of the volume. At 710, the image planes of interest are calculated from the 3-D reference coordinate system and at 712 a 3-D data set is acquired (unless already completed). At 714, one or more ultrasound images are displayed corresponding to the image planes of interest.

[0032] FIG. 8 illustrates a processing sequence to obtain ultrasound image planes in a real-time continuously updated 3-D data set in accordance with an embodiment of the present invention. At 802, patient specific information is estimated or entered. The patient specific information is representative of the shape or size of the volume. At 804, image planes of interest are calculated in the 3-D reference coordinate system. In the example of FIG. 8, a reference plane has not yet been calculated at 804. Instead, at 804, the image planes are calculated relative to the origin of a predetermined 3-D reference coordinate system. The image planes are projected into the predetermined 3D reference coordinate system based upon the assumption that the reference coordinate system and the subsequently acquired volumetric data set will be mapped in a known manner within, and relative to the origin, of the 3-D reference coordinate system.

[0033] At 806, the probe is positioned to obtain a select reference plane through the volume of interest. At 808, a 3-D data set of volumetric ultrasound data is acquired. The volumetric data set is mapped into the 3-D reference coordinate system such that the reference plane is positioned at a known location and orientation relative to the origin of the 3-D reference court system. At 810, ultrasound images are obtained for the image planes calculated at 804. At 812, the ultrasound images are displayed.

[0034] It is understood that the above methods and systems may be utilized in connection with a variety of patient types, diagnoses, organs and the like. For example, the organ may be the heart, head, liver, arm, leg and the like.

[0035] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. A diagnostic ultrasound system for automatically displaying multiple planes from a volume of interest, the system comprising:

a transducer acquiring ultrasound data associated with a volume of interest that includes a target object;

an user interface for designating a reference plane within the volume on interest; and

a processor module receiving patient specific information representative of at least one of a shape and size of the target object, the processor module mapping the reference plane and the ultrasound data into a 3D reference coordinate system, the processor module automatically calculating at least one plane of interest within the 3D reference coordinate system based on the reference plane and the patient specific information.

2. The system of claim 1, wherein the patient specific information constitutes a geometric parameter that includes at least one of an identification of a type of organ, a diameter, a circumference, a length, and organ dimension.

3. The system of claim 1, wherein the processor module calculates a translation distance and a rotation distance from the reference plane to determine a position and orientation of the plane of interest within the 3D reference coordinate system, wherein the translation and rotation distance is based on an age of a patient.

4. The system of claim 1, wherein the patient specific information constitutes a non-geometric parameter including at least one of age, weight and sex.

5. The system of claim 1, further comprising memory storing a 3-D data set of ultrasound data associated with the volume of interest, the reference plane representing a user defined plane within the volume of interest, wherein the 3-D data set is acquired before the plane of interest is calculated.

6. The system of claim 1, further comprising memory storing and repeatedly updating 3-D data set of ultrasound data associated with the volume of interest, the reference plane representing a user defined plane within the volume of interest, wherein the 3-D data set is continuously updated before and after the plane of interest is calculated.

7. The system of claim 1, further comprising memory storing a table including predefined sets of translation and rotation values in connection with corresponding planes of interest, each set of translation and rotation values being associated with the patient specific information.

8. The system of claim 1, wherein the patient specific information includes an age of a fetus and the processor module calculates a relation between the plane of interest and the reference plane based on a plurality of preceding fetal studies of other patients.

9. A method for automatically displaying multiple ultrasound planes from a volume of interest, the method comprising:

acquiring ultrasound data associated with a volume of interest that includes a target object;

designating a reference plane within the volume on interest;

receiving patient specific information representative of at least one of a shape and size of the target object;

mapping the reference plane and the ultrasound data into a 3D reference coordinate system; and

automatically calculating at least one plane of interest within the 3D reference coordinate system based on the reference plane and the patient specific information.

10. The method of claim 9, wherein the patient specific information constitutes a geometric parameter that includes at least one of an identification of a type of organ, a diameter, a circumference, a length, and organ dimension.

11. The method of claim 9, further comprising calculating a translation distance and a rotation distance from the reference plane to determine a position and orientation of the plane of interest within the 3D reference coordinate system, wherein the translation and rotation distance is based on an age of a patient.

12. The method of claim 9, wherein the patient specific information constitutes a non-geometric parameter including at least one of age, weight and sex.

13. The method of claim 9, further comprising memory storing a 3-D data set of ultrasound data associated with the volume of interest, the reference plane representing a user defined plane within the volume of interest, wherein the 3-D data set is acquired before the plane of interest is calculated.

14. The method of claim 9, wherein the volume of interest includes a fetus, the method further comprising measuring an anatomic structure within the reference plane and based upon the measurement of the anatomic structure, determining an age of the fetus.

15. The method of claim 9, wherein a 3-D data set of ultrasound data is obtained after the plane of interest has been calculated.

* * * * *

专利名称(译)	用于基于患者特定信息自动获得超声图像平面的系统和方法		
公开(公告)号	US20070249935A1	公开(公告)日	2007-10-25
申请号	US11/434432	申请日	2006-05-15
[标]申请(专利权)人(译)	通用电气公司		
申请(专利权)人(译)	通用电气公司		
当前申请(专利权)人(译)	通用电气公司		
[标]发明人	DESCHINGER HARALD FALKENSAMMER PETER		
发明人	DESCHINGER, HARALD FALKENSAMMER, PETER		
IPC分类号	A61B8/00		
CPC分类号	A61B8/0866 A61B8/483 A61B8/523		
优先权	60/793908 2006-04-20 US		
外部链接	Espacenet USPTO		

摘要(译)

提供诊断超声系统，用于从感兴趣的体积自动显示多个平面。该系统包括换能器，用于获取与其中具有目标对象的感兴趣体积相关联的超声数据。它们系统还包括用户界面，用于指定感兴趣的体积内的参考平面。处理器模块接收表示目标对象的形状和大小中的至少一个的患者特定信息，并将参考平面和超声数据映射到3D参考坐标系中。处理器模块基于参考平面和患者特定信息自动计算3D参考坐标系内的至少一个感兴趣的平面。