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(54) COMPOSITE ULTRASOUND 3D INTRACARDIAC VOLUME BY AGGREGATION OF INDIVIDUAL ULTRASOUND 3D INTRACARDIAC SEGMENTS

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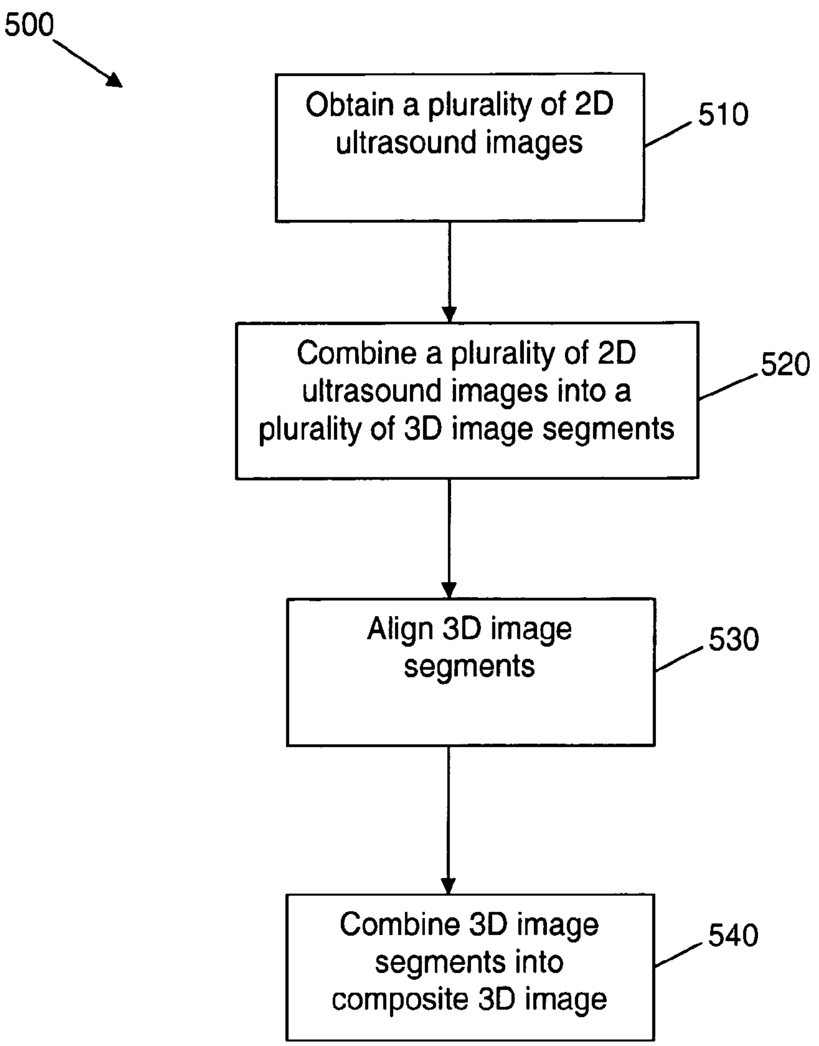
(57) **ABSTRACT**

Embodiments of the presently described technology provide a method for ultrasound imaging. The method includes obtaining a plurality of ultrasound 3D image segments of an anatomy and combining the plurality of 3D image segments into a composite 3D image of the anatomy. Embodiments of the presently described technology also provide a system for ultrasound imaging. The system includes a computing device combining a plurality of ultrasound 2D images of an anatomy obtained by a transducer array into one or more 3D image segments and aggregating the 3D image segments into a composite 3D image of the anatomy.



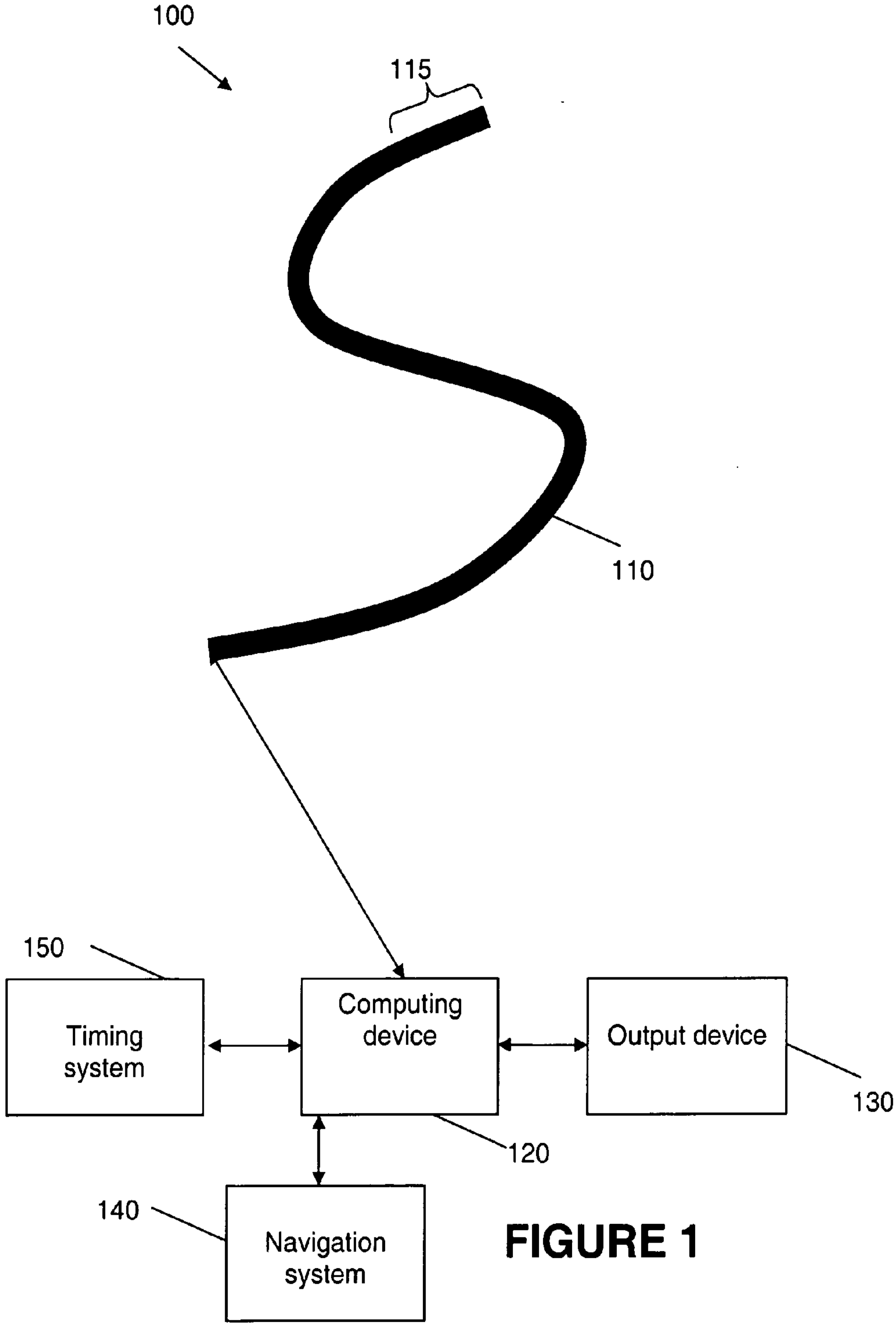

100
115
110
150
Timing system
Computing device
Output device
130
120
140
Navigation system

FIGURE 1

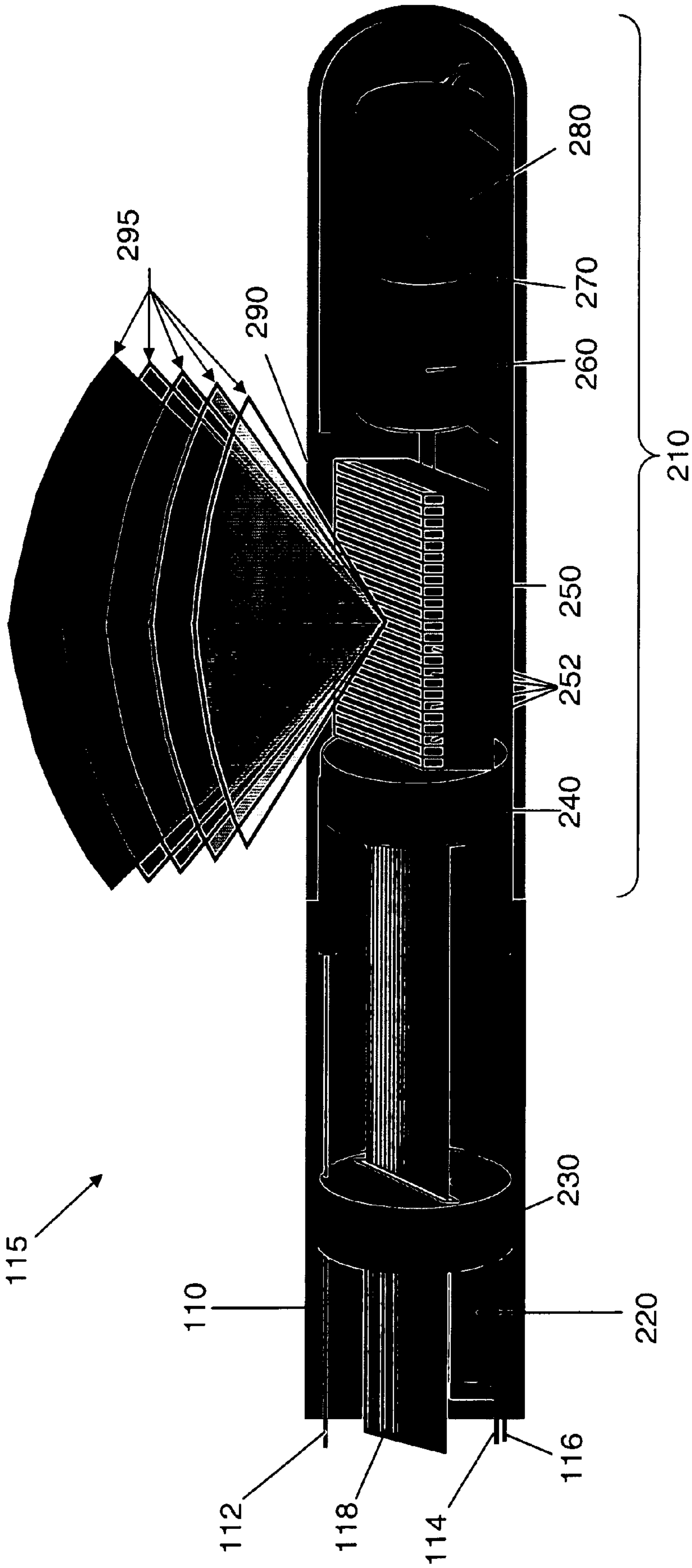

295
290
280
270
260
210
250
252
240
230
220
115
110
112
118
114
116

FIGURE 2

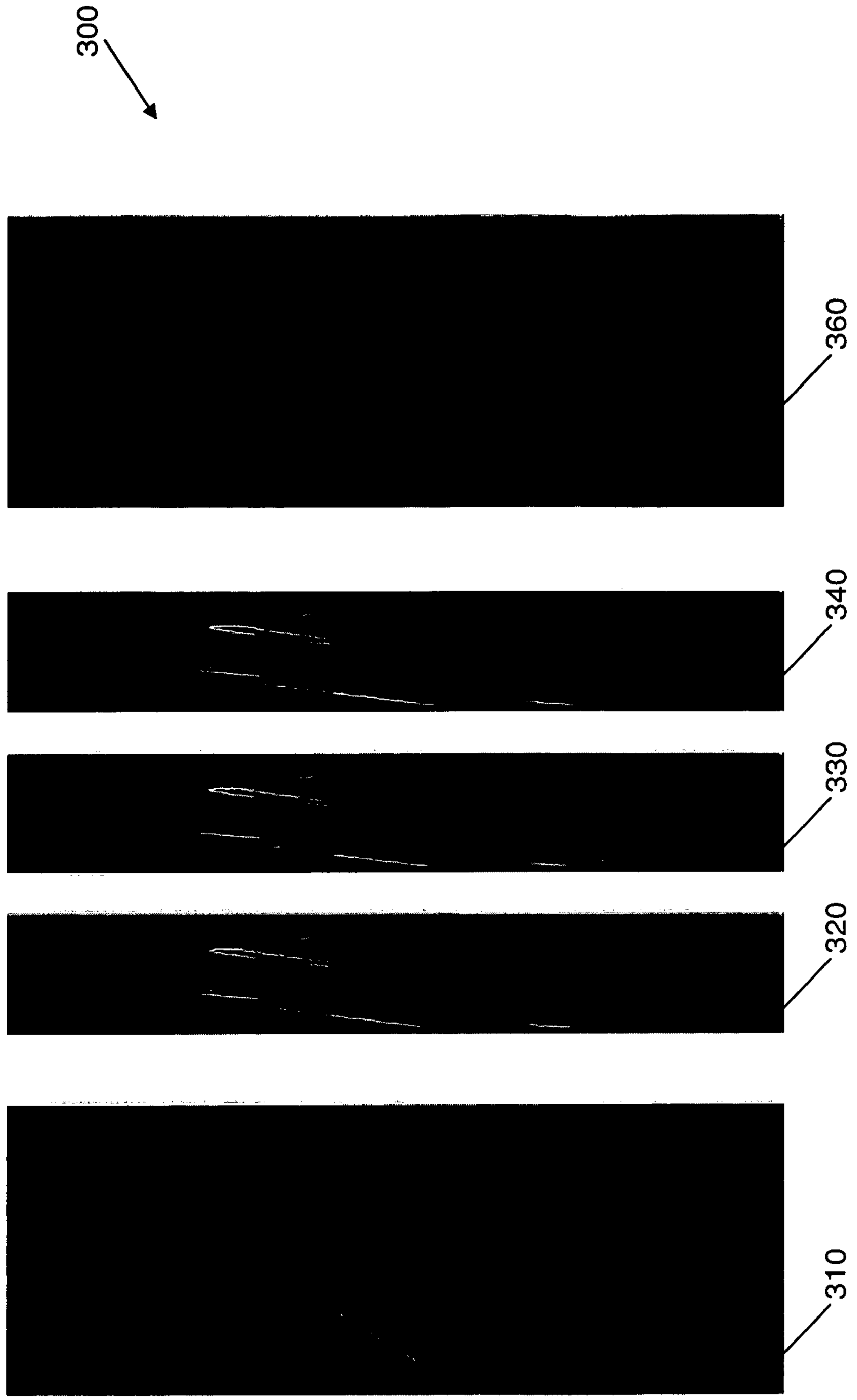


FIGURE 3

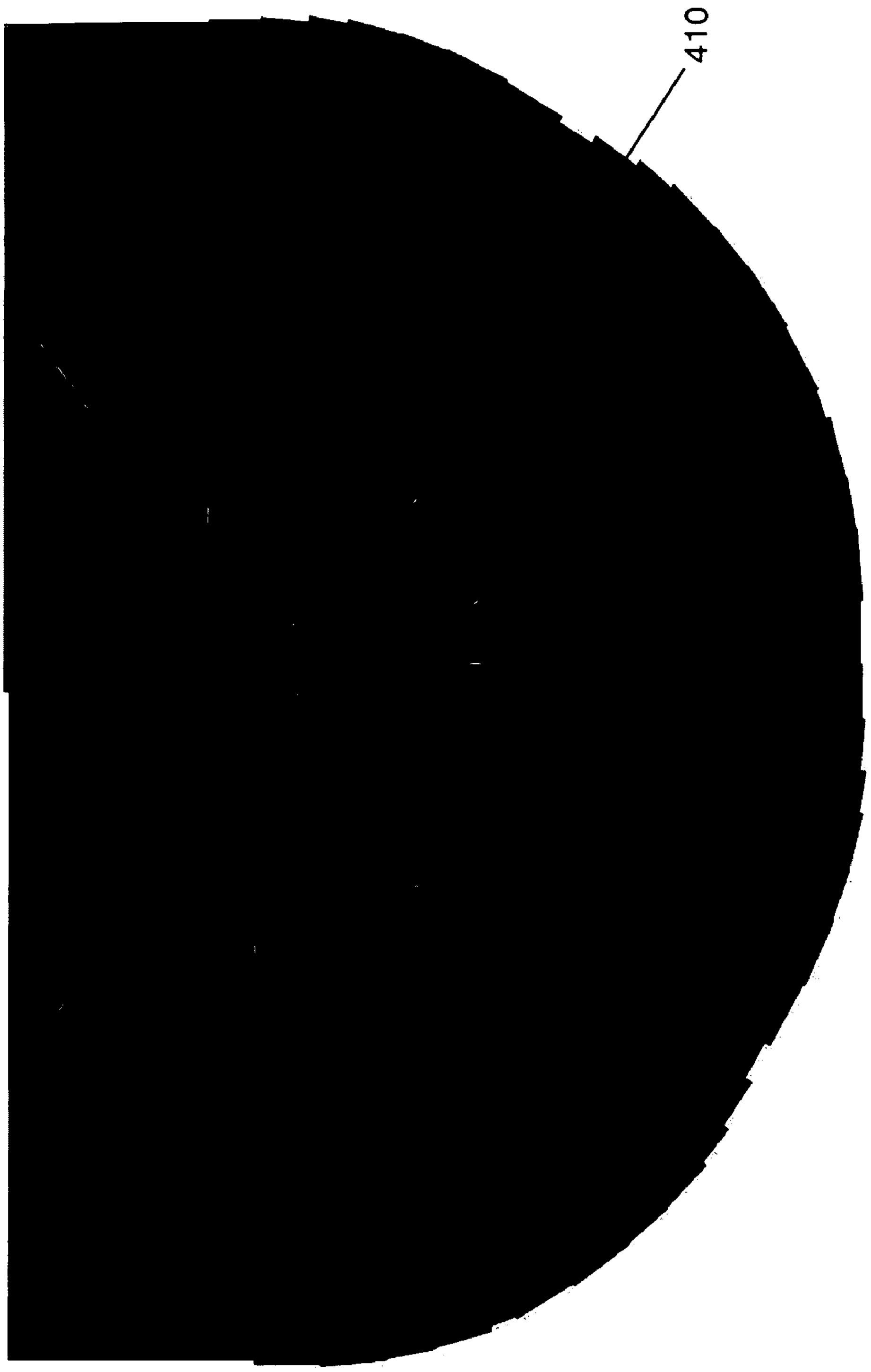


FIGURE 4

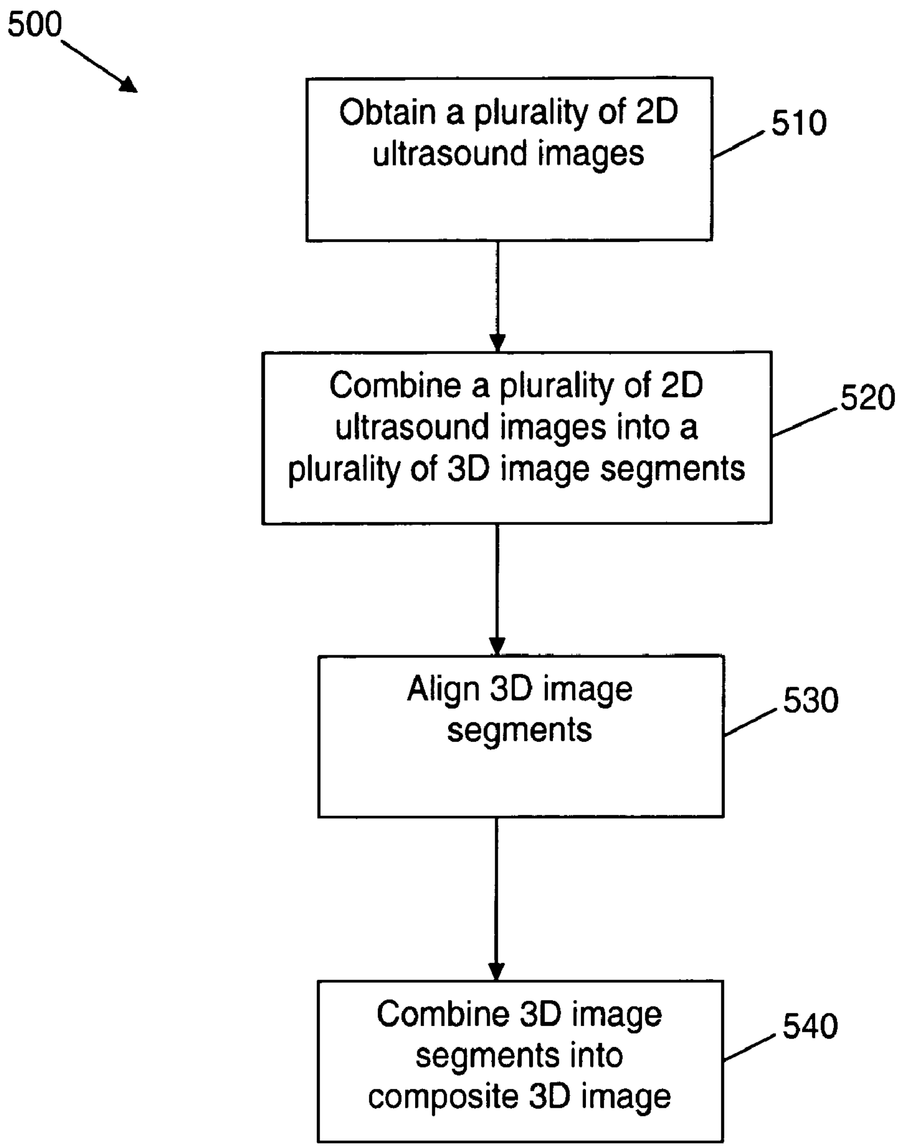

500
Obtain a plurality of 2D ultrasound images
510
Combine a plurality of 2D ultrasound images into a plurality of 3D image segments
520
Align 3D image segments
530
Combine 3D image segments into composite 3D image
540

FIGURE 5

COMPOSITE ULTRASOUND 3D INTRACARDIAC VOLUME BY AGGREGATION OF INDIVIDUAL ULTRASOUND 3D INTRACARDIAC SEGMENTS

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/853,108 (the "'108 application"), filed Oct. 20, 2006, entitled "Composite Ultrasound 3D Intracardiac Volume by Aggregation of Individual Ultrasound 3D Intracardiac Segments." The '108 application is incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

[0002] The presently described technology relates to ultrasound imaging. Specifically, embodiments of the presently described invention relate to improved systems and methods for three-dimensional ("3D") ultrasound imaging.

[0003] Existing intracardiac echocardiography ("ICE") ultrasound imaging technology provides a two-dimensional ("2D") view of a patient anatomy, such as a patient's heart. This technology includes mounting a transducer array on the exterior of a catheter, inserting the transducer array into a patient's heart, activating the elements of the array to transmit and receive ultrasound echoes and translating or converting the received ultrasound echoes into a 2D image.

[0004] Some ICE ultrasound imaging technology also provides a 3D volume image of a patient anatomy, such as a patient's heart. However, the current systems and methods for providing such 3D volumes provide a very limited imaged volume.

[0005] Although these technologies allow clinicians to get an internal view of the cardiac anatomy and provide a means to deliver image guided therapy, it makes it difficult for the clinician to get an exact indication of where the ICE catheter is located. For example, 2D images typically do not provide sufficient information to determine the location of the catheter with respect to structures in the cardiac anatomy. In another example, 3D images obtained by existing ultrasound technologies provide a very limited volumetric image. In a sense, the existing 3D images are akin to shining a spotlight to view a large area. While the area illuminated by the spotlight can be viewed, other areas that are not illuminated cannot be viewed.

[0006] Thus, existing technologies do not provide sufficient imaging information about the volume surrounding the ICE catheter. One way to solve this problem could be to provide more 3D imaging information. That is, by providing a wider ultrasound-rendered volume of the cardiac anatomy and/or anatomical structure than currently available from existing technologies, clinicians can be able to better identify the catheter location with respect to the patient's anatomy. This volume could be rendered in real-time (or, created as additional imaging information/data is obtained by a transducer array) and provide immediate feedback to clinicians and accordingly assist in the determination of the ICE catheter location.

[0007] Therefore, a need exists for an improved system and method for providing an increased imaged volume using catheter-based ultrasound transducer arrays. Meeting such a need can provide clinicians with additional imaging information in patients' cardiac anatomies.

BRIEF DESCRIPTION OF THE INVENTION

[0008] Embodiments of the presently described technology provide a method for ultrasound imaging. The method includes obtaining a plurality of ultrasound 3D image segments of an anatomy and combining the plurality of 3D image segments into a composite 3D image of the anatomy.

[0009] Embodiments of the presently described technology provide a system for ultrasound imaging. The system includes a computing device combining a plurality of ultrasound 2D images of an anatomy obtained by a transducer array into one or more 3D image segments and aggregating the 3D image segments into a composite 3D image of the anatomy.

[0010] Embodiments of the presently described technology provide a computer-readable storage medium comprising a set of instructions for a computing device. The set of instructions include an aggregation routine configured to aggregate a plurality of 3D ultrasound image segments into a composite 3D image of an anatomy, where the 3D image segments are formed by combining a plurality of 2D ultrasound images of an anatomy.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0011] FIG. **1** illustrates a catheter-based ultrasound imaging system according to an embodiment of the presently described technology.

[0012] FIG. **2** illustrates distal end of elongated body with a transducer tip in accordance with an embodiment of the presently described technology.

[0013] FIG. **3** illustrates a group of 3D image segments obtained in accordance with an embodiment of the presently described technology.

[0014] FIG. **4** illustrates a composite 3D image formed or created from a plurality of 3D image segments by computing device in accordance with an embodiment of the presently described technology.

[0015] FIG. **5** illustrates a flowchart of a method for aggregating a plurality of 3D image segments into a composite 3D image in accordance with an embodiment of the presently described technology.

[0016] The foregoing summary, as well as the following detailed description of certain embodiments of the presently described technology, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, certain embodiments are shown in the drawings. It should be understood, however, that the present invention is not limited to the arrangements and instrumentality shown in the attached drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Embodiments of the presently described technology provide a mechanism visualize in 3D an intracardiac volume/anatomical structure. In addition, embodiments of the presently described technology provide a mechanism to a clinician to identify the location of an ultrasound imaging intracardiac echocardiographic catheter (that is, a point of view). Embodiments of the presently described technology also allow 3D volume to be rendered in real-time as 3D images are acquired or via post processing activity by aggregating previously acquired 3D ultrasound intracardiac segments.

[0018] Current ICE catheters can only provide 2D images. There is no 3D ICE catheter available in the marketplace that is being actively used by clinicians to diagnose and treat patients. Furthermore, there are no composite 3D intracardiac volumes that are being created using currently available catheter probes. Embodiments of the presently described technology extend the use of 3D ICE catheters by introducing the concept of aggregation of the acquired 3D ultrasound images to create a composite volume.

[0019] FIG. **1** illustrates a catheter-based ultrasound imaging system **100** according to an embodiment of the presently described technology. System **100** includes an elongated body **110**, a computing device **120**, an output device **130**, a navigation system **140** and a timing system **150**. Elongated body **110** is in communication with computing device **120**. Computing device **120** is in communication with output device **130**, navigation system **140** and timing system **150**. Any one or more of elongated body **110**, computing device **120** and output device **130** can communicate data via one or more digital connections. The digital connections can be a wired or wireless connection, for example.

[0020] Elongated body **110** includes any elongated device or apparatus capable of having a transducer array mounted proximate a distal end **115** of the body **110**. For example, in a preferred embodiment, elongated body **110** includes a catheter. In other embodiments, elongated body **110** can include an endoscope, for example.

[0021] Computing device **120** includes any device capable of carrying out a set of instructions for a computer. For example, computing device **120** can include a CPU. In another example, computing device **120** can include an ultrasound imaging CPU. As described in more detail below, computing device **120** is capable of directing a transducer array to obtain 2D ultrasound images in a plurality of imaging planes in a patient anatomy. For example, computing device **120** can direct a linear phased transducer array to obtain one or more 2D images. Computing device **120** can direct which plane should be imaged and when an ultrasound image should be obtained by array.

[0022] Output device **130** includes any device capable of displaying or presenting images obtained by a transducer array mounted on or in elongated body **110**. For example, output device **130** can include a printer or a CRT monitor.

[0023] Navigation system **140** includes any system, apparatus or device capable of tracking or determining a position of a transducer array or distal end **115** of elongated body **110**. For example, navigation system **140** can determine a position of an array or distal end **115** using one or more electrical fields and the impedance of the array or catheter, or using magnetism, such as through an Industry Standard Coil Architecture ("ISCA") system. The position data can include the 3D position (that is, x, y and z) or change in position (that is, Ax, Ay and Az) of the array or distal end **115** of body **110**. This position data can be communicated to computing device **120**.

[0024] Timing system **150** includes any system, apparatus or device capable of measuring a recurring event and reporting the sequence of the recurring event with respect to time to computing device **150**. For example, timing system **150** can include a device capable of measuring a rate of repeated cardiac and/or respiratory motion and reporting this rate to computing device **120**. In such an example, timing system **150** can include an ECG system.

[0025] In another example, timing system **150** can include an imaging device that measures the movement of a patient's diaphragm with respect to time. The imaging device can be, for example, an x-ray imaging device. By measuring diaphragm movement with respect to time, timing system **150** can measure a patient's breathing patterns with respect to time.

[0026] In another example, timing system **150** can include expiration sensors. These sensors can measure or calculate the oxygen concentration going in and/or out of a patient's lungs. These measurements or calculations can be used by timing system **150** to determine a patient's breathing patterns with respect to time.

[0027] An ultrasound transducer array is mounted proximate distal end **115** of elongated body **110**. The array is capable of obtaining 2D ultrasound images in a plurality of imaging planes of a patient anatomy. For example, a linear transducer array capable of obtaining 2D ultrasound images of a patient anatomy can be mounted on or inside distal end **115** of a catheter. Such an array can be manually or mechanically moved or rotated so as to obtain 2D images of a plurality of imaging planes. In another example, a transducer array capable of rotating about the longitudinal axis of elongated body **110** can be mounted on or inside distal end **115** of elongated body **110**.

[0028] FIG. **2** illustrates distal end **115** of elongated body **110** with a transducer tip **210** in accordance with an embodiment of the presently described technology. FIG. **2** illustrates distal end **115** of elongated body **110** of FIG. **1**. Distal end **115** includes a transducer tip **210**. Transducer tip **210** can be formed separate from elongated body **110** and subsequently attached or connected to distal end **115** of body **110**. In such an embodiment, tip **210** can be fixed to body **110** so that once tip **210** is connected to body **110**, tip **210** cannot be removed from body **110**. Alternatively, tip **210** can be attached to body **110** in such a way that tip **210** can later be easily removed from body **110**.

[0029] Alternatively, transducer tip **210** can be an integral part of body **110**. That is, tip **210** can be part of body **110** and inseparable from body **110**.

[0030] In an embodiment, tip **210** can be formed of a combination of materials to ensure that tip **210** is a rigid, non-flexible body. For example, tip **210** can be formed of polyurethane that is surrounded by a polyimide "jacket" that provides the stiffness and rigidity desired for tip **210**. Tip **210** can be a rigid, non-flexible body to ensure that tip **210** cannot be bent so as to damage transducer array **250** enclosed therein.

[0031] Transducer tip **210** can include a non-rotating seal or bulkhead **230**, a cylindrical bearing **240**, a transducer array **250** comprising a plurality of ultrasound transducer elements **252**, a gearbox **260**, a motor **270**, a temperature sensor **280** and an ultrasonic output window **290**.

[0032] In an embodiment of the presently described technology, elongated body **110** includes one or more pull wires/cables **112**, a temperature sensor wire/cable **114**, a motor wire/cable **116** and one or more transducer communication cables **118**. Temperature sensor wire/cable **114** connects temperature sensor **280** to computing device **120** and permits communication of temperature data collected by sensor **280** to device **120**. Motor wire/cable **116** connects motor **270** to device **120** and provides a communication path for device **120**

to control the rotation of array **250**, as described in more detail below. Transducer communication cable(s) **118** connects transducer array **250** to device **120** and provides a communication path for device **120** to cause array **250** to transmit ultrasound beams and for ultrasound echoes received by array **250** to be transmitted to device **120** (as a signal, for example). Computing device **120** can direct array **250** when to obtain an image and/or which 2D plane to image.

[0033] In addition, in an embodiment, elongated body **110** and/or tip **210** can include a fluid reservoir **220** to accommodate thermal expansion and/or to compensate for fluid loss during storage of elongated body **110** and/or tip **210**.

[0034] That is, voids in elongated body **110** and/or tip **210** can include a fluid. Seal **230** can assist in preventing, impeding or stopping fluid from passing from one side of seal **230** to the other.

[0035] In an embodiment of the presently described technology, elongated body **110** is a catheter capable of being intravenously steered in a plurality of directions. For example, body **110** can includes a four-way steerable body with a diameter of between 9 and 10 French (~3π mm). Body **110** can be steered using one or more of pull wires/cables **112**. In embodiments of the presently described technology, body **110** and tip **210** can be inserted into the cardiac vessels of a patient to obtain ultrasound images.

[0036] In an embodiment, transducer array **250** is a one-dimensional ("ID") array. Array **250** can include several transducer elements **252**. For example, array **250** can comprise 64 elements **252** with a pitch of 0.110 nm. That is, array **250** can include a single row of 64 transducer array elements **252**. Array elements **252** can be formed of a piezoelectric material. Array **250** can be a linear phased array that operates at a range of frequencies. For example, array **250** can operate at a center frequency of approximately 6.5 MHz, with an operating range of 4-10 MHz.

[0037] Window **290** can permit ultrasound beams transmitted by array **250** to pass through tip **210**. In an embodiment, window **290** is formed of polyurethane. In another embodiment, window **290** can act as a lens to focus ultrasound beams towards a focal point. That is, window **290** can help to focus ultrasound beams transmitted by array **250**. In addition, window **290** can act as a lens to reduce an effect of coupling fluid and the material that tip **210** is formed of on an ultrasound beam transmitted by array **250**.

[0038] In an embodiment of the presently described technology, array **250** is capable of obtaining a plurality of 2D images **295** in different imaging planes by being rotated about an axis. That is, transducer array **250** can be capable of rotating about the longitudinal axis of tip **210** or elongated body **110** as array **250** transmits and receives ultrasound beams. In an embodiment, array **250** is arranged for oscillatory rotation about the longitudinal axis of tip **210** (that is, back and forth, rather than continuously around). For example, transducer array **250** can obtain 2D image data from a variety of positions as it oscillates about the longitudinal axis of tip **210**. One or more hard stops can be placed in tip **210** to limit rotation (that is, prevent 360° rotation about the longitudinal axis of tip **210**) and initialize alignment of transducer array **250**, window **290**, and motor cable/wire **116**. In another embodiment, array **250** is arranged for 360° rotation about the longitudinal axis of tip **210**. The rotation of array **250** can be limited in radial distance and/or speed. For example, transducer array **250** can be capable of rotating ±30° and obtaining 2D images at 7 vol/second.

[0039] Array **250** can be connected to device **120** via cable (s) **118**, as described above. Cable(s) **118** can run through all or a portion of tip **210** and/or elongated body **110**. In an embodiment, cylindrical bearing **240** can be provided to permit array **250** to rotate without causing communication cables **118** to also be rotated. That is, bearing **240** can permit array **250** to rotate about the longitudinal axis of tip **210** while keeping cables **118** stationary with respect to the longitudinal axis of tip **210**.

[0040] In an embodiment, motor **270** and gearbox **260** are included in tip **210**. For example, motor **270** and gearbox **260** can be located distal to transducer array **250** in tip **250**. Control signals sent from device **120** to motor **270** can be used to cause motor **270** to become activated and cause transducer array **250** to rotate, stop array **250** from rotating, or cause array **250** to rotate in the same or different direction. For example, in an embodiment, transducer array **250** and motor **270**.

[0041] Motion caused by motor **270** can be translated to array **250** via one or more gears in gear box **260**. For example, motor **270** can cause one or more gears in gear box **260** to rotate, which in turn cause one or more other gears or the array **250** itself to rotate. In an embodiment, array **250** is connected to a gear in gear box **260** that is rotated to cause rotation of array **250**. In another embodiment, a coupling or drive shaft is positioned between motor **270** and gearbox **260** and transducer array **250**.

[0042] In operation, array **250** obtains a plurality of 2D ultrasound images in a plurality of imaging planes. These images are then combined into a plurality of 3D image segments. The plurality of 3D image segments is then aggregated into a composite 3D image. This composite 3D image can provide more image information than any one of the 3D image segments. For example, the composite 3D image can provide a wider angle of view of a patient anatomy.

[0043] Computing device **120** causes transducer array **250** to transmit ultrasound waves to image a plurality of imaging planes. The received ultrasound echoes are communicated from array **250** to device **120** as an electronic signal. Device **120** then forms a 2D image from the received signal. Computing device **120** can cause output device **130** to display or present any one or more of the 2D images. For example, output device **130** can print up a 2D image or display an image on a CRT monitor.

[0044] Once at least a plurality of 2D images is obtained from at least a plurality of imaging planes, computing device **120** can combine the 2D images (or image data associated with the 2D images) into at least one 3D image. This 3D image is referred to as a 3D image segment. FIG. **3** illustrates a group **300** of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** obtained in accordance with an embodiment of the presently described technology. Each of image segments **310-360** is a 3D image segment formed or created by computing device **120** combining a plurality of 2D images.

[0045] In an embodiment, computing device **120** combines 2D images into a 3D image segment **310-360** after all 2D images for that 3D image segment **310**, **320**, **330**, **340**, **350** or **360** have been obtained. That is, in this embodiment, computing device **120** does not combine the 2D images until all the 2D images are obtained. The 3D image segment **310**, **320**, **330**, **340**, **350**, **360** is then formed or created in post-image acquisition processing.

[0046] In another embodiment, computing device **120** combines or adds 2D images (or image data) to other 2D images or 3D image segments **310**, **320**, **330**, **340**, **350**, **360** during image acquisition. That is, computing device **120** does not wait for all 2D images to be obtained before combining the 2D images or adding a recently acquired 2D image to a 3D image segment **310**, **320**, **330**, **340**, **350**, **360**. In this way, computing device **120** combines each 2D image with other 2D images or a 3D image segment **310**, **320**, **330**, **340**, **350**, **360** as each 2D image is obtained.

[0047] FIG. **4** illustrates a composite 3D image **410** formed or created from a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** by computing device **120** in accordance with an embodiment of the presently described technology. Once a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** are obtained or formed, computing device **120** aggregates or combines the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** into one or more composite 3D images **410**. While FIG. **3** illustrates five 3D image segments **310**, **320**, **330**, **340**, **350**, **360**, a larger or smaller number of 3D image segments can be combined by computing device **120** to form a composite 3D image **410**. For example, as few as two 3D image segments **310**, **320**, **330**, **340**, **350**, **360**, or a number of image segments **310**, **320**, **330**, **340**, **350**, **360** greater than **5**, can be combined by computing device **120** to form a composite 3D image **410**.

[0048] Computing device **120** can aggregate the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** into so that a portion of a plurality of the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** into overlaps one another, for example. In another example, computing device **120** aggregates the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** into end-to-end. By analogy, this type of aggregation is similar to laying a series of photographs taken of different sections of a horizon next to one another to obtain a full image of the entire horizon. This type of aggregation provides an improvement over existing 3D ultrasound images as the field-of-view of a patient anatomy is considerably greater than 3D images obtained via traditional ultrasound imaging techniques. That is, the anatomical volume represented in composite image **410** is greater than that of any one of image segments **310**, **320**, **330**, **340**, **350**, **360**. For example, as shown in FIG. **4**, composite 3D image **410** provides a wider field of view of a patient anatomy than any single one of 3D image segments **310**, **320**, **330**, **340**, **350**, **360**.

[0049] Once the 3D composite image **410** is obtained, computing device **120** causes output device **130** to present composite image **410**. For example, computing device **120** can cause output device **130** to print out a copy of the composite image **410** or display the composite image **410** on a monitor.

[0050] In an embodiment of the presently described technology, computing device **120** combines each of the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** for a given composite 3D image **410** as each 3D image segment **310**, **320**, **330**, **340**, **350**, **360** is obtained, or formed by computing device **120**. That is, rather than waiting until all 3D image segments **310**, **320**, **330**, **340**, **350**, **360** for a given composite 3D image **410** are formed before combining them, computing device **120** combines each 3D image segment **310**, **320**, **330**, **340**, **350**, **360** with other 3D image segments **310**, **320**, **330**, **340**, **350**, **360** as soon as each 3D image segment is formed.

[0051] In an embodiment of the presently described technology, computing device **120** combines the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** for a given composite 3D image **410** after all 3D image segments **310**, **320**, **330**, **340**, **350**, **360** are obtained, or formed by computing device **120**. That is, rather than combining each 3D image segment **310**, **320**, **330**, **340**, **350**, **360** with other 3D image segments **310**, **320**, **330**, **340**, **350**, **360** as soon as each 3D image segment is formed, computing device **120** waits until all 3D image segments **310**, **320**, **330**, **340**, **350**, **360** for a given composite 3D image **410** are formed before combining them.

[0052] In an embodiment of the presently described technology, computing device **120** aligns a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** prior to combining the segments into composite 3D image **410**. The alignment can include spatial and/or temporal alignment. For spatial alignment, computing device **120** aligns a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** to provide the proper spatial layout of segments **310**, **320**, **330**, **340**, **350**, **360** in composite image **410**.

[0053] In an embodiment of the presently described technology, spatial alignment can include computing device **120** aligning each of a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** with respect to one or more anatomical landmarks imaged in each of the plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360**. The anatomical landmarks can be identified by a user of computing device **120**. For example, a user can select one or more anatomical landmarks in each 2D image or 3D image segment **310**, **320**, **330**, **340**, **350**, **360** displayed on output device **130** by computing device **120**. Computing device **120** can then align each 3D image segment **310**, **320**, **330**, **340**, **350**, **360** in composite 3D image **410** by using these user-defined anatomical landmarks. For example, computing device **120** make sure that the same anatomical landmark in adjacent 3D image segments **310**, **320**, **330**, **340**, **350**, **360** is shown in the same spatial location in composite 3D image **410** by overlapping the adjacent 3D image segments **310**, **320**, **330**, **340**, **350**, **360**.

[0054] In another embodiment, spatial alignment can include computing device **120** aligning each of a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** with respect to position data of transducer array **250** or tip **210**. As described above, position data of transducer array **250** or distal end **115** of elongated body **110** (such as of tip **210**, for example) can be obtained by navigation system **140** and communicated to computing device **120**. Computing device **120** can associate this position data with 2D images and/or 3D image segments **310**, **320**, **330**, **340**, **350**, **360**. This position data can then be used to provide an accurate spatial layout of each 3D image segment **310**, **320**, **330**, **340**, **350**, **360** with respect to one another in composite 3D image **410**.

[0055] For temporal alignment, computing device **120** combines 3D image segments **310**, **320**, **330**, **340**, **350**, **360** so that image data in each of the combined segments **310**, **320**, **330**, **340**, **350**, **360** is obtained at an approximately similar time. By approximately similar time, it is meant that the 2D images used to form one or more of image segments **310**, **320**, **330**, **340**, **350**, **360** are obtained by transducer array **250** within the same time period or within a similar repeated time period. For example, in an embodiment of the presently described technology, timing system **150** can notify computing device **120** of a patient's heart rate and/or breathing patterns with respect to time, as described above. Using this information, computing device **120** can direct array **250** to obtain a 2D ultrasound image at or about the same time. For example, computing device **120** can direct array **250** to obtain a 2D image only when a patient's ECG is at a given peak or valley, or when a patient exhales or inhales (that is, takes a breath). In another embodiment, computing device **120** tracks the time at which each 2D image is obtained by array **250** with respect to a patient's ECG or breathing pattern (provided by timing system **150**). Then, in order to temporally align the 3D image segments **310**, **320**, **330**, **340**, **350**, **360** for a composite 3D image **410**, computing device **120** only uses 2D images or 3D image segments **310**, **320**, **330**, **340**, **350**, **360** to form composite 3D image **410** that were obtained at or at about the same time with respect to a patient's heart beat or breathing pattern.

[0056] In an embodiment of the presently described technology, computing device **120** includes a computer-readable storage medium comprising a set of instructions for a computer. The computer-readable storage medium can be embodied in a memory device capable of being read by a computer. The set of instructions can be embodied in one or more sets of computer code and/or software algorithms. The set of instructions includes an aggregation routine. The aggregation routine is configured or written to cause computing device **120** to aggregate a plurality of 3D image segments **310**, **320**, **330**, **340**, **350**, **360** into a composite 3D image **410** of an anatomy, as described above. The aggregation routine can also be configured to form each of said 3D image segments **310**, **320**, **330**, **340**, **350**, **360** by combining a plurality of 2D ultrasound images, as described in the various embodiments above.

[0057] FIG. **5** illustrates a flowchart of a method **500** for aggregating a plurality of 3D image segments into a composite 3D image in accordance with an embodiment of the presently described technology. First, at step **510**, a plurality of 2D ultrasound images are obtained, as described above. Next, at step **520**, a plurality of the 2D ultrasound images obtained at step **510** are combined to form a plurality of 3D image segments, as described above. Next, at step **530**, a plurality of 3D image segments formed or created at step **520** are aligned with respect to time and/or position, as described above. Next at step **540**, a plurality of 3D image segments formed at step **520** are combined into a composite 3D image, also as described above.

[0058] In an embodiment of the presently described technology, steps **510** and **520** overlap one another. That is, step **510** need not be completed before step **520** is completed. As described above, as each 2D image is obtained, it can be combined to other 2D images or 3D image segments, rather than waiting for all 2D images to be obtained before combining them into a 3D image segment.

[0059] In an embodiment of the presently described technology, steps **520** and **530** overlap one another. That is, step **520** need not be completed before step **530** is completed. As described above, as each 3D image segment is formed, it can be aggregated with other 3D image segments, rather than waiting for all 3D image segments to be formed before aggregating them into a 3D composite image. That is, the aggregation of the 3D image segments can be either in real-time (that is, as the image segments are formed) or as part of post processing of retrospective 3D images segments that were acquired previously.

[0060] Embodiments of the presently described technology can be used by clinicians in delivering therapy for various procedures and to image cardiac structures. In addition, this technology can also be used in non-medical applications to provide 3D visualizations of internal structures that require an invasive means to reach the structure of interest.

[0061] While particular elements, embodiments and applications of the present invention have been shown and described, it is understood that the invention is not limited thereto since modifications may be made by those skilled in the art, particularly in light of the foregoing teaching. It is therefore contemplated by the appended claims to cover such modifications and incorporate those features that come within the spirit and scope of the invention.

What is claimed is:

1. A method for ultrasound imaging, said method including:

obtaining a plurality of ultrasound three-dimensional ("3D") image segments of an anatomy; and

combining said plurality of 3D image segments into a composite 3D image of said anatomy.

2. The method of claim **1**, wherein said obtaining step includes obtaining a plurality of two-dimensional ("2D") ultrasound images from an ultrasound transducer array mounted proximate a distal end of a catheter and combining said plurality of 2D images into each of said 3D image segments.

3. The method of claim **1**, wherein each of said 2D images is combined with other 2D images as each of said 2D images is obtained.

4. The method of claim **1**, wherein said plurality of 2D images for a given 3D image segment are combined after all of said plurality of 2D images are obtained.

5. The method of claim **1**, wherein said combining step includes combining each of said 3D image segments as each 3D image segment is obtained.

6. The method of claim **1**, further including aligning a plurality of said 3D image segments.

7. The method of claim **6**, wherein said aligning step includes aligning a plurality of said 3D image segments with respect to time.

8. The method of claim **7**, wherein said aligning step includes aligning said plurality of 3D image segments with respect to one or more of cardiac and respiratory motion.

9. The method of claim **1**, wherein said composite 3D image represents a greater volume of said anatomy than any one of said 3D image segments.

10. A system for ultrasound imaging, said system including:

a computing device combining a plurality of ultrasound two-dimensional ("2D") images of an anatomy obtained by a transducer array into one or more three-dimensional ("3D") image segments and aggregating said 3D image segments into a composite 3D image of said anatomy.

11. The system of claim **10**, wherein said transducer array is mounted proximate a distal end of a catheter.

12. The system of claim **10**, wherein said computing device combines said 2D images as each of said 2D images is obtained.

13. The system of claim **10**, wherein said computing device aggregates said 3D image segments as each 3D image segment is created.

14. The system of claim **10**, wherein said computing device aligns a plurality of said 3D image segments.

15. The system of claim **14**, wherein said computing device aligns a plurality of said 3D image segments with respect to time.

16. The system of claim **10**, wherein said composite 3D image represents a greater volume of said anatomy than any one of said 3D image segments.

17. A computer-readable storage medium comprising a set of instructions for a computing device, said set of instructions including:

an aggregation routine configured to aggregate a plurality of three-dimensional ("3D") ultrasound image segments into a composite 3D image of an anatomy, said 3D image segments formed by combining a plurality of two-dimensional ("2D") ultrasound images of an anatomy.

18. The computer-readable storage medium of claim **17**, wherein said 2D images are obtained using an ultrasound transducer array mounted proximate a distal end of a catheter and inserted into a heart of a patient.

19. The computer-readable storage medium of claim **17**, wherein said aggregation routine combines each of said 2D images with other 2D images as each of said 2D images is obtained.

20. The computer-readable storage medium of claim **17**, wherein said aggregation routine aggregates each of said 3D image segments as each 3D image segment is obtained.

* * * * *

patsnap

专利名称(译)	复合超声3D心内容积通过聚集个别超声3D心内节段

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摘要(译)

当前描述的技术的实施例提供了用于超声成像的方法。该方法包括获得解剖结构的多个超声3D图像片段并将多个3D图像片段组合成解剖结构的合成3D图像。当前描述的技术的实施例还提供了用于超声成像的系统。该系统包括计算设备，该计算设备将由换能器阵列获得的解剖结构的多个超声2D图像组合成一个或多个3D图像片段，并将3D图像片段聚合成解剖结构的复合3D图像。