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**(54) ULTRASOUND ACQUISITION FEEDBACK GUIDANCE TO A TARGET VIEW**

ULTRASCHALLERFASSUNGSRÜCKKOPPLUNGSFÜHRUNG ZU EINER ZIELANSICHT

GUIDAGE PAR RETOUR D'ACQUISITION D'ULTRASONS VERS UNE VUE CIBLÉE

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## Description

### FIELD OF THE INVENTION

**[0001]** The present invention relates to ultrasound image matching for user guidance and, more particularly, to such matching to a pre-existing image to achieve a target view.

### BACKGROUND OF THE INVENTION

**[0002]** Successful ultrasound scanning relies strongly on the training and experience of the user. To avoid artifacts, the user has to place the probe in the right position, i.e., to find a good acoustic window, for imaging. Conventionally, this is done solely based on real-time ultrasound images displayed onscreen. Although experienced users are usually capable of recognizing image degradation, and of improving image quality accordingly by moving the probe to a better position, less experienced users might acquire compromised images because of inferior hand-eye coordination and less awareness of artifacts. Acquisition of a set of standard views of a body organ of interest is a challenging task for healthcare workers having little or no background in radiology.

**[0003]** "Real-Time Scan Assistant for Echocardiography", Snare, S. R. et al., IEEE Transactions in Ultrasonics, Ferroelectrics, and Frequency Control (2012) (hereinafter "the Snare publication") describes an image-processing approach applied to two-dimensional (2D) four-chamber cardiac images to output a metric of the quality of the obtained view.

**[0004]** United States Patent Publication No. 2012/0065510 to Snare, S. R. et al. discloses comparing a live image, from an ultrasound imaging probe, to a target image via correlation between contours fitted to one or more frames of the live image and the target image. Snare further discloses a processor calculating changes needed from the current probe position in order to relocate the probe into a new position that would result in the acquisition of additional ultrasound data that may be used to generate an image that more closely matches the target image.

### SUMMARY OF THE INVENTION

**[0005]** What is proposed herein below is directed to addressing one or more of the above concerns.

**[0006]** The Snare publication rates the current view, but does not guide the user toward a target view.

**[0007]** A means by which the clinician can be automatically guided along a path to achieving a target view is needed.

**[0008]** According to the present invention, an apparatus according to claim 1 and a computer readable medium according to claim 9 are presented.

**[0009]** The apparatus according to the present invention is configured for guidance in acquiring ultrasound

imaging of a subject to achieve a target view and comprises: an imaging probe for emitting ultrasound to the subject and for, in response, receiving a current ultrasound view; an image matching module configured matching the received image to a pre-existing image; a user assistance module; and a database comprising a plurality of images of an organ or a vessel of interest and/or surrounding tissue from multiple imaging subjects. The database is a statistical database which is organized as a state space, wherein the plurality of images comprised in said database are incorporated into the state space and labeled with image attributes including a viewed image anatomy, an image quality and a probe position and orientation on a superficial anatomy, and wherein the image matching module is further configured for estimating a location of said received view in the state space, wherein dimensions of each point within said state space correspond to the image attributes. The user assistance module is configured for selecting, based on said current ultrasound view and its location in the state space, a respective trajectory in said state space toward said target view.

**[0010]** In a sub-aspect, the probe has a current placement, and at least one of showing and instructing occurs on how to move the probe from its current placement so as to thereby realize the achieving of the target view.

**[0011]** In one sub-aspect, a match between the target view and the received view is detected.

**[0012]** As a further sub-aspect, an apparatus automatically, and without need for user intervention, performing either or both a) user notification responsive to the detecting of the match; and by acquiring image data, via the probe, responsive to the detecting of the match.

**[0013]** In one other sub-aspect, the target view is a standard anatomical view that, prior to a time of the guidance, has already been set by an authoritative medical entity.

**[0014]** In yet another sub-aspect, feedback is presented that instructs, or shows, how to proceed toward the goal of achieving the target view.

**[0015]** In another variation as a sub-aspect of the view registering, instruction is provided on how to move the probe for the achieving of the target view. A speaker for the instructing issues audible language instructions, instructions are issued on a display, or both the speaker and the display are provided for these purposes.

**[0016]** In a particular version of the above-mentioned aspect, a location of the received view in a state space is estimated.

**[0017]** In a particular sub-version of this, Doppler settings are, automatically by default, initialized according to those that were pre-set for the target view in building a database organized as the state space.

**[0018]** As a sub-version of this, a selection is made, based on the current ultrasound view, of a respective trajectory in the state space toward the target view.

**[0019]** As a further sub-version, the feedback is based on the selection.

**[0020]** In a specific sub-version, a scanner configured for forming the state space does so by steps that include: acquiring, via the scanner and from multiple imaging subjects, the plurality of images specialized for a specific body organ or vessel such that the organ or vessel, and/or surrounding tissue, are depicted in all of the plural images; and labeling the images with the respective image attributes.

**[0021]** In a further sub-version, forming the state space includes linking, to particular images such as those other than target, i.e., standard, images, respective instructions on how to navigate the probe from the particular image to another one of the images.

**[0022]** Details of the novel, real-time, interactive visual guidance technology are set forth further below, with the aid of the following drawings, which are not drawn to scale.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0023]**

FIG. 1 is a schematic diagram of an ultrasound clinician interactive guidance apparatus in accordance with the present invention;

FIG. 2 is a flow chart of overall operation of one implementation of the apparatus of FIG. 1, in accordance with the present invention;

FIG. 3 is a flow chart of an example of image matching preparation, in accordance with the present invention;

FIG. 4 is a flow chart of state space preparation, in accordance with the present invention; and

FIG. 5 is a conceptual and screen display diagram of examples of user feedback, in accordance with the present invention; and

FIG. 6 is a conceptual illustration of examples of user feedback and feedback generation, in accordance with the present invention.

#### DETAILED DESCRIPTION OF EMBODIMENTS

**[0024]** FIG. 1 depicts, by way of illustrative and non-limitative example, an ultrasound clinician interactive guidance apparatus 100. The apparatus 100 includes, among other component devices, a controller 104, an image matching module 108, a user assistance module 112, a memory 116, a scanner 120, a display 124, a speaker 128 and user controls 132. The image matching module 108 includes an image registering module 136 and/or a state space processing module 140. The scanner includes, among other component devices, an imaging probe 144.

**[0025]** Operationally, an overall procedure 200 for ultrasound clinician interactive guidance is as follows, as shown in FIG. 2. As a preliminary step, an authoritative medical entity such as a physician, medical board, medical standards organization, or hospital sets standard ultrasound views for the body organ, or vessel, of interest (step S204). The set of standard views is specified for use on the apparatus 100 (step S208). One or more image matching references are prepared (step S212) which

is explained in more detail below with reference to FIG. 3. The clinician selects a scan type, which may be for a particular body organ such as the heart, or vessel such as a particular artery (step S216). The apparatus 100 pulls up the corresponding image matching reference (step S218). The apparatus 100 determines which target view from among the standard views is to be acquired next. The apparatus 100 also now loads Doppler settings that have been pre-selected for the target view, as discussed below in connection with FIG. 4. In short, Doppler settings are, automatically by default, initialized according to those that were pre-set for the target view in building a database organized as the state space (step S220). The apparatus 100 indicates to the user how, based on textbook guidelines for example, to place the imaging probe 144 on the superficial anatomy of the imaging subject, such as an animal or human patient (step S224). The user, i.e., clinician, positions the probe 144 (step S228). If the user guidance function apparatus 100 operates based on a state space (step S232), the state space processing module 140 is implemented and makes an estimate of the location, in the state space, of the current, or "live", view acquired via the probe 144 (step S236). If, on the other hand, the state space processing module 140 is not implemented (step S232) but the image registering module 136 is implemented, the current view is registered to a corresponding position, and orientation, in a three-dimensional (3D) reference image (step S240). If it is now determined that the current view does not match, or sufficiently represent, the target view (step S244), the apparatus 100 gives user feedback that instructs, or shows, how to proceed toward the goal of achieving the target view (step S248), and processing branches back to the user positioning step S228. Description in more detail of the feedback is provided further below in the discussion accompanying FIGs. 5 and 6. If, instead, a match has been attained (step S244) and automatic acquisition is to be performed (step S252), the current view is recorded for further analysis, e.g., by a physician (step S256). If, on the other hand, a match has been attained (step S244) and user-actuated acquisition is to be performed (step S252), a green light is lit on the probe 144 or elsewhere on the scanner, such as on a console that houses the user controls 132 (step S260).

**[0026]** The image matching reference preparation step (S212) is described in more detail in the flow chart of FIG. 3. With reference to FIG. 3, if image matching is to be based on a three-dimensional (3D) anatomical atlas as the image matching reference (step S310), and the atlas is to be a statistical atlas (step S320), a statistical atlas is prepared (step S330). The statistical atlas is built based on the computed tomography (CT) and/or magnetic resonance imaging (MR) scans of a wide variety of subjects to cover anatomical variation. It may be stored on a hard

drive which is part of the memory 116. Per voxel, the atlas includes a distribution of image intensities reflective of individual members of the population. Neighboring information is also included for each voxel. Image matching to achieve registration is performed quicker due to the statistical nature of the statistical atlas. If, on the other hand, image matching is to be based on an anatomical atlas that is not a statistical atlas (steps S310, S320), the anatomical atlas is prepared as the 3D image matching reference, typically via CT and/or MR scans from a wide variety of subjects (step S340). If, instead of an atlas (step S310), CT and/or MR scans of the same patient are to be used to build the 3D image matching reference (step S350), the "same-patient" reference is prepared (step S360). If, on the other hand, the same-patient CT/MR scans are not available or are otherwise not to be used (step S350), and a state space is to be used (step S370), a state space is prepared (step S380). Preparation of the state space is described in more detail immediately below in connection with FIG. 4.

**[0027]** A state space preparation process 400 involves building a statistical database of a set of hundreds of scans of and around the organ, or vessel, of interest from multiple imaging subjects. The database is organized as a state space. Images to be incorporated into the state space are labeled with attributes such as viewed image anatomy, image quality, and corresponding probe position and orientation on the superficial anatomy. A subset of this set of images is the set of goal states, corresponding to the standard ultrasound views with good image quality. The images of the database can be described as points within a state space whose dimensions are the image attributes. Within the state space, it is possible to define a spatial relationship between ultrasound images, and in particular a trajectory between any ultrasound image and any of the goal images.

**[0028]** The images to be acquired for incorporation into the state space are specialized for a specific body organ, or vessel, such that the organ or vessel, and/or surrounding tissue, are depicted in each image. The process 400 is initialized to a first imaging subject, a first target view, a first trajectory and a first image (step S404). Thus, the respective pointers or counters are zeroed out. A current image is acquired via the imaging probe 144 (step S408). Attributes of the image are recorded and the current image is labeled with its attributes (step S412). The recording can be done in part automatically and in part via entry by the person building the database. The current image may be labeled according to: the viewed anatomy (e.g., carotid (left, right, common, internal, external, bulb, bifurcation, proximal, medial, distal, longitudinal, transverse, oblique, etc.) such as jugular vein, thyroid gland, vertebral bodies, vertebral artery, vertebral vein, subclavian artery, etc.; the position and orientation of the probe 144 with respect to the superficial anatomy to obtain these images (e.g., anterior, anterior, posterior, cranial, caudal, lateral, medial, neck, clavicle, mandible, Adam's apple, horizontal, vertical, oblique); optionally the current

imaging mode and settings (e.g., for B-mode, power, focal depth, harmonics, spatial compounding; for color flow, gain, maximum velocity, color box orientation, sample volume size; and for spectral Doppler, maximum velocity and Doppler angle); and optionally the presence of artifacts and a measure of image quality (e.g., contact artifacts, good ultrasound contact and average image contrast). Labeling of the current imaging mode and settings is done automatically. Since navigation toward a target view ordinarily would proceed B-mode image to B-mode image, modes such as Doppler can ordinarily be, in effect, withdrawn from the navigation process. For example, these settings can be supplied by default automatically at the outset, as in step S220 above. The setting values were created according to control adjustments made by the database builder specifically for the target view during database build up. If, in the course of user navigation, the user inadvertently or for whatever reason, changes these settings, the resulting state space distance would automatically at some point of time, or points of time, during navigation, result in feedback offering user instruction for effectively restoring these settings. Alternatively, the target view Doppler settings need not be supplied by default upon initialization; instead, user feedback due to the resulting state space distance would, in the course of user navigation or at the outset, instruct the appropriate adjustments to the settings.

**[0029]** The current image acquired may have been acquired via ultrasound contact that is less than good. This would be done intentionally, so that matching to this image, once it is in the database, allows the deficient contact to be detected. If the contact is deficient (step S416), the person building the database applies or reapplies acoustic coupling medium, such as gel, restores the probe 144 to the same position and orientation with respect to the imaging subject for an improved image (step S420). Otherwise, if the contact was not deficient (step S416), the database builder, via probe movement or adjustment of imaging settings, prepares for a next image acquisition (step S422). The movement or adjustment is made so as to navigate toward the target image.

**[0030]** In either event, i.e., whether or not contact was sufficient, processing now points to that next image (step S424). The image is acquired (step S428). The attributes are recorded in part manually and in part automatically (step S432). The most recent probe movement, contact adjustment or imaging setting adjustment, ordinarily for B-mode, made in the corresponding above steps S420, S422 is entered or selected by the database builder, or automatically, and linked to the previous image, i.e., the image acquired just prior to step S428 (step S436). The entry could be, with respect to probe position, "left", "right", "up" or "down." Here, "up" would be mean generally in the head to toe direction. The entry could instead or in addition be, with respect orientation, i.e., tilting, "left", "right", "up", or "down." The entry could additionally or instead be, with respect in place rotation of the probe 144, "clockwise" or "counterclockwise." In each of these

options, distance or magnitude need not be recorded, because the updating of the feedback loop in steps S228 to S248 occurs in real time. In particular, the database image having the location closest, according to Euclidean distance for example, to the estimate made in step S236 dynamically keeps the user on a trajectory toward the target view. Even if, during operation, a user wanders into another trajectory, that other trajectory will similarly navigate toward the target view. With regard to probe contact, the entry or selection by the database builder may be "reapply gel to probe and return to same position and orientation." For imaging setting changes, the automatic selection may be, for example, "increase imaging depth."

**[0031]** If the current view is not the target view (step S440), processing returns to step S416. Otherwise, if the current view is the target view as evidenced by actuation of the appropriate user control 132 by the database builder (step S440), and another trajectory is to be recorded for the current target view of the current imaging subject (step S444), the database builder is advised, via an on-screen message, to enter Doppler mode settings (step S446). Interactively, according to a series of screen prompts and responsive actuations by the database builder, the Doppler settings are stored as attributes of the target view (step S448). The trajectory pointer is incremented (step S450) and return is made to step S408. If, on the other hand, no such further trajectory is to be recorded (step S444), but another target view for the current imaging subject is to be used in building up the database (step S452), the view pointer is incremented (step S456) and return is likewise made to step S408. If, however, no target view for the current imaging subject remains in terms of building up the database (step S452), but a next imaging subject is to be used in building the database (step S460), the subject pointer is incremented (step S464) and return is likewise made to step S408.

**[0032]** FIG. 5 provides examples of the user feedback of step S248, which can take the form of onscreen illustrations or messages, or audible language.

**[0033]** An ultrasound image representative of a current view 502 such as a B-mode image can be displayed alongside a cross-sectional image 504 derived from a 3D reference image 503 stored on a hard drive, i.e., from an atlas or from a 3D image constructed from patient-specific CT and/or MR scans. The cross-sectional image 504, here of a body organ 505, i.e., the heart, has been sectioned and enhanced to spatially indicate where the received (or "live") view registers to the reference image. Thus an enhanced region 506, that is colored for example, corresponds spatially with where the current image would cut into the atlas. To show the clinician how to proceed in navigating toward a current target view, a graphic indication 508 of the plane of the current target view 510 can be added to the onscreen presentation. Also, instead of showing the current view 502 as a separate image, the ultrasound image can be fused 512 to the cross-sectional image 504 such as by a pixel for pixel

replacement. Here too, the graphic indication 508 can be added.

**[0034]** Alternatively or in addition, screen messages or audible language instructions can guide the clinician. Thus, for the position/tilt 514 of the probe 144, four possible indications 516-522 are "right", "left", "up" and "down", just as in the state space based embodiment. Likewise, as in the state space based embodiment, in-place rotation 524 can be "clockwise" 526 or "counter-clockwise" 528.

**[0035]** The registration in step S240 involves image-based pattern matching of the current view 502 to the 3D reference image and a coordinate transformation on the current view to bring it into registration with the 3D image in accordance with the matching. The feedback instructions, based on the transformation, can be representative of a single kind, or more than one kind, of suggested probe movement 514, 524.

**[0036]** For the state space based embodiment, the estimate in step S236 is made as a result of pattern recognition from comparisons between the current view 502 and the database images acquired in the acquisition steps S408, S428. The one or more types of feedback instructions (i.e., probe movement, probe contact and imaging settings) linked to the current database image are presented.

**[0037]** FIG. 6 is a specific example of user feedback and feedback generation. This example relates to the left medial common carotid artery 601 and acquiring a standard view of the artery. A transducer array face graphic 604 is shown in an oblique position 608, representative of a current placement 610 of the probe 144, and in a non-oblique position 612. The transducer array may be a linear array or a matrix array. Mandible graphics 616 and clavicle graphics 620 are also shown in FIG. 6. A current graphic 624 corresponds conceptually to the current view 502, and a target graphic 628 corresponds conceptually to the target view 510. In addition, both graphics 624, 628 may be displayed onscreen in addition to, or in place of, any other graphic or ultrasound image representative of the current view 502.

**[0038]** In the state space embodiment, the viewed anatomy label for a matched database image is "left medial common carotid artery, oblique view." The probe position label is "midway between clavicle and mandible." The clavicle and mandible graphics 616, 620 represent surrounding tissue. The probe orientation label is "oblique." The imaging mode label is "B-mode." An imaging setting label is "spatial compounding." An artifact label is "artifact-free." An image quality label is "good image contrast", based for example on average pixel intensity. All of the labels can be displayed, on the display 124, upon matching to the database image 604.

**[0039]** If an image quality attribute of the matched database image indicated lack of good probe contact, rather than the actual indication here of "good" probe contact by virtue of good image quality, this current imaging condition could interfere with further matching to database

images in navigating a trajectory toward a standard view. Accordingly, improvement of the contact would predominate over other navigational considerations. This would then constitute an example of selecting an optimal trajectory in the state space, and is evidenced by the issuance of a user feedback message like "reapply gel and restore probe to the same location and orientation" that was linked to the current database image in the linking step S436.

**[0040]** However, since the image quality label indicates that contact is good, a different instruction, that was stored during database building in step S436, is sent for viewing on the display 124. The instruction here would be the instruction 526 to "rotate in-place clockwise." This is indicated by illustrative arrows 632. The resulting movement of the probe 144 by the clinician is, as mentioned herein above, monitored in real time via the feedback loop in steps S228 to S248. The instruction is resent for display repeatedly, but will change in the event of the current view 502 matching to a new database image, such as that corresponding to the target view 510.

**[0041]** In the case of the 3D image embodiment, the instruction 526 "rotate clockwise" is derivable almost by definition, since the only transformation involved in registering the current view 502 to the 3D reference image is, in fact, the clockwise rotation. In a less clearcut case, where reaching the target view 510 entails, for instance, probe in-place rotation and translation, whether rotation or translation predominates is decided by the apparatus 100. The criteria can involve thresholds selected based on empirical experience, although, for example, location will ordinarily dominate over tilting until the probe location is close to that needed for a target view 510.

**[0042]** Guidance in acquiring ultrasound imaging of a subject to achieve a target view, such as a standard view, entails emitting ultrasound to the subject and receiving, in response, a current ultrasound view; matching the received image to a pre-existing image, such as a three-dimensional reference image; and, for user assistance, generating, based on the matching, feedback for the guidance. The reference image may be a statistical atlas or it may be derived from patient-specific CT or MR scans. The pre-existing image may instead be a database image corresponding to a state in a state space. The feedback can be an image derived from the reference image; a graphic indication of a plane of the target view; the received view fused to an image derived from the reference image; or the received view and an image derived from said reference image, the derived image appearing concurrently and enhanced to spatially indicate where the received view registers to the reference image. The target view may be a view of a body organ, or vessel, of the subject. Both the atlas and database can be specialized for imaging of a user selected organ, or vessel, and its surrounding tissue.

**[0043]** In addition to making diagnostic cardiac examination performable by nurses or other clinicians who may be untrained specifically in sonography, the interactive

visual guidance apparatus 100 can guide novice sonographers. Alternatively, the novel visual feedback of the apparatus 100 can speed up the work flow of trained or experienced sonographers.

**[0044]** While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

**[0045]** For example, the probe 144 may alternatively or additionally use tactile feedback on the appropriate probe movement toward a standard view.

**[0046]** Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. Any reference signs in the claims should not be construed as limiting the scope.

**[0047]** A computer program can be stored momentarily, temporarily or for a longer period of time on a suitable computer-readable medium, such as an optical storage medium or a solid-state medium. Such a medium is non-transitory only in the sense of not being a transitory, propagating signal, but includes other forms of computer-readable media such as register memory, processor cache, RAM and other volatile memory.

**[0048]** A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

## Claims

1. An apparatus configured for guidance in acquiring ultrasound imaging of a subject to achieve a target view, said apparatus comprising:

an imaging probe (144) for emitting ultrasound to said subject and for, in response, receiving a current ultrasound view;

an image matching module (108) configured for matching the received view to a pre-existing image;

a user assistance module (112); and

a database comprising a plurality of images of an organ or a vessel of interest and/or surrounding tissue from multiple imaging subjects;

**characterized in that** the database is a statistical database which is organized as a state space, wherein the plurality of images comprised in said database are incorporated into the state space and labeled with image attributes including a viewed image anatomy, an image quality and a probe position and orientation on

- a superficial anatomy, and **in that** the image matching module is further configured for estimating a location of said received view in the state space, wherein dimensions of each point within said state space correspond to the image attributes, and wherein the user assistance module is configured for selecting, based on said current ultrasound view and its location in the state space, a respective trajectory in said state space toward said target view. 5
2. The apparatus of claim 1, said probe having a current placement, said apparatus configured for at least one of showing and instructing how to move said probe from its current placement so as to thereby realize the achieving of said target view (510). 10
3. The apparatus of claim 1, wherein said user assistance module being further configured for detecting a match (S244) between said target view and the received view. 15
4. The apparatus of claim 3, configured for automatically, and without need for user intervention, either or both of: a) performing user notification responsive to said detecting of said match; and b) acquiring image data (S252), via said probe, responsive to said detecting of said match. 20
5. The apparatus of claim 1, further configured for presenting feedback (S248) that instructs, or shows, how to proceed toward the goal of achieving the target view. 25
6. The apparatus of claim 1, further configured for, automatically by default, initializing Doppler settings according to those that were pre-set for said target view in building the database organized as said state space (S404-S464). 30
7. The apparatus of claim 1, further comprising a scanner (120), configured for forming said state space, said forming comprising: 35
- acquiring, via said scanner and from multiple imaging subjects, the plurality of images specialized for a specific body organ, or vessel, such that said organ or vessel, and/or surrounding tissue, are depicted in all of the plural images; and 40
- labeling the plural images with the respective image attributes. 45
8. The apparatus of claim 7, said forming further comprising linking (S436), to particular images from among said plural images, respective instructions on how to navigate said probe from said particular image to another one of said plural images. 50

9. A computer readable medium embodying a computer program for guidance in acquiring ultrasound imaging of a subject to achieve a target view, said program having instructions executable by a processor for performing a plurality of acts, from among said acts being the acts of: 5

emitting ultrasound to said subject;  
in response, receiving, via an imaging probe, a current ultrasound view;  
matching the received view to a pre-existing image (503), said pre-existing image being one of a plurality of images of an organ or a vessel of interest and/or surrounding tissue from multiple imaging subjects, which plurality of images are each labeled with image attributes including a viewed image anatomy, an image quality and a probe position and orientation on a superficial anatomy, and which plurality of images are comprised in a statistical database which is organized as a state space;  
estimating a location of said received view in the state space, wherein dimensions of each point within said state space correspond to the image attributes; and,  
based on said matching, generating feedback for said guidance by selecting, based on said current ultrasound view and its location in the state space, a respective trajectory in said state space toward said target view. 10

#### Patentansprüche

1. Vorrichtung, die zur Führung beim Erfassen einer Ultraschallabbildung eines Subjekts konfiguriert ist, um eine Zielansicht zu erreichen, wobei die Vorrichtung umfasst: 35
- eine Abbildungssonde (144) zum Emittieren von Ultraschall an das Subjekt und als Antwort darauf, Empfangen einer aktuellen Ultraschallansicht;  
ein Bildanpassungsmodul (108), das zum Anpassen der empfangenen Ansicht an ein bereits bestehendes Bild konfiguriert ist;  
ein Benutzerassistenzmodul (112); und  
eine Datenbank, die eine Vielzahl von Bildern eines Organs oder eines Gefäßes von Interesse und/oder umgebenden Gewebes von mehrfachen Abbildungssubjekten umfasst;  
**dadurch gekennzeichnet, dass** die Datenbank eine statistische Datenbank ist, die als ein Zustandsraum organisiert ist, wobei die Vielzahl von in der Datenbank enthaltenen Bildern in dem Zustandsraum eingebaut sind und mit Bildeigenschaften gekennzeichnet sind, die eine betrachtete Bildanatomie, eine Bildqualität und 40

- eine Sondenposition und -ausrichtung auf einer oberflächlichen Anatomie einschließen, und dass das Bildanpassungsmodul weiter konfiguriert ist, um einen Standort der empfangenen Ansicht in dem Zustandsraum zu schätzen, wobei Dimensionen von jedem Punkt in dem Zustandsraum den Bildeigenschaften entsprechen, und wobei das Benutzerassistenzmodul konfiguriert ist, um, basierend auf der aktuellen Ultraschallansicht und ihrem Standort in dem Zustandsraum, eine jeweilige Bahn in dem Zustandsraum auf die Zielansicht auszuwählen.
2. Vorrichtung nach Anspruch 1, wobei die Sonde eine aktuelle Platzierung aufweist, wobei die Vorrichtung konfiguriert ist, um mindestens eins zu zeigen oder anzuweisen, wie die Sonde von ihrer aktuellen Platzierung bewegt werden soll, um das Erreichen der Zielansicht (510) dabei zu realisieren.
3. Vorrichtung nach Anspruch 1, wobei das Benutzerassistenzmodul weiter konfiguriert ist, um eine Anpassung (S244) zwischen der Zielansicht und der empfangenen Ansicht zu detektieren.
4. Vorrichtung nach Anspruch 3, konfiguriert, um automatisch, und ohne Bedarf an Benutzereingriff, eins oder beide von: a) Benutzermitteilung als Antwort auf das Detektieren der Anpassung durchzuführen; und b) Bilddaten (S252) über die Sonde als Antwort auf das Detektieren der Anpassung zu erfassen.
5. Vorrichtung nach Anspruch 1, weiter konfiguriert, um Rückmeldung (S248) darzustellen, die anweist oder zeigt, wie auf das Ziel des Erreichens der Zielansicht zugegangen werden soll.
6. Vorrichtung nach Anspruch 1, weiter konfiguriert, um, automatisch standardmäßig, Dopplereinstellungen gemäß denen einzuleiten, die für die Zielansicht beim Aufbau der Datenbank voreingestellt wurden, die als der Zustandsraum (S404-S464) organisiert ist.
7. Vorrichtung nach Anspruch 1, weiter einen Scanner (120) umfassend, der konfiguriert ist, um den Zustandsraum zu bilden, das Bilden umfassend:
- Erfassen, über den Scanner und von mehrfachen Abbildungssubjekten, der Vielzahl von Bildern, die für ein spezifisches Körperorgan, oder Gefäß spezialisiert sind, sodass das Organ oder Gefäß, und/oder umgebendes Gewebe, in allen der vielen Bilder abgebildet sind; und Kennzeichnen der vielen Bilder mit den jeweiligen Bildeigenschaften.
8. Vorrichtung nach Anspruch 1, wobei das Bilden weiter Verbinden (S436), an bestimmten Bildern von den vielen Bildern, von jeweiligen Anweisungen umfasst, wie die Sonde von dem bestimmten Bild zu einem anderen der vielen Bilder gesteuert werden soll.
9. Computerlesbares Medium, das ein Computerprogramm zur Führung beim Erfassen von Ultraschallabbildung eines Subjekts verkörpert, um eine Zielansicht zu erreichen, wobei das Programm Anweisungen aufweist, die von einem Prozessor ausführbar sind, um eine Vielzahl von Handlungen durchzuführen, wobei unter den Handlungen die folgenden Handlungen vorhanden sind:
- Emittieren von Ultraschall an das Subjekt; als Antwort darauf, Empfangen, über eine Abbildungssonde, einer aktuellen Ultraschallansicht; Anpassen der empfangenen Ansicht an ein bereits bestehendes Bild (503), wobei das bereits bestehende Bild eins einer Vielzahl von Bildern eines Organs oder eines Gefäßes von Interesse und/oder umgebenden Gewebes von mehrfachen Abbildungssubjekten ist, wobei die Vielzahl von Bildern jeweils mit Bildeigenschaften gekennzeichnet sind, die eine betrachtete Bildanatomie, eine Bildqualität und eine Sondenposition und -ausrichtung auf einer oberflächlichen Anatomie einschließen, und wobei die Vielzahl von Bildern in einer statistischen Datenbank umfasst sind, die als ein Zustandsraum organisiert ist; Schätzen eines Standorts der empfangenen Ansicht in dem Zustandsraum, wobei Dimensionen von jedem Punkt in dem Zustandsraum den Bildeigenschaften entsprechen; und, basierend auf der Anpassung, Erzeugen von Rückmeldung für die Führung durch Auswählen, basierend auf der aktuellen Ultraschallansicht und ihrem Standort in dem Zustandsraum, einer jeweiligen Bahn in dem Zustandsraum auf die Zielansicht.
- Revendications**
1. Appareil configuré pour le guidage dans l'acquisition d'imagerie par ultrasons d'un sujet pour parvenir à une vue cible, ledit appareil comprenant :
- une sonde d'imagerie (144) pour émettre des ultrasons vers ledit sujet et pour, en réponse, recevoir une vue courante par ultrasons ; un module de concordance d'image (108) configuré pour faire concorder la vue reçue à une image préexistante ; un module d'aide à l'utilisateur (112) ; et une base de données comprenant une pluralité

- d'images d'un organe ou d'un vaisseau d'intérêt et/ou de tissu environnant provenant de multiples sujets d'imagerie ;  
**caractérisé en ce que** la base de données est une base de données statistiques qui est organisée comme un espace d'état, dans lequel la pluralité d'images comprises dans ladite base de données est incorporée dans l'espace d'état et étiquetée avec des attributs d'image incluant une anatomie d'image observée, une qualité d'image et une position de sonde et une orientation sur une anatomie superficielle, et **en ce que** le module de concordance d'image est en outre configuré pour évaluer une localisation de ladite vue reçue dans l'espace d'état, dans lequel des dimensions de chaque point dans ledit espace d'état correspondent aux attributs d'image, et dans lequel le module d'aide à l'utilisateur est configuré pour sélectionner, sur la base de ladite vue courante par ultrasons et de sa localisation dans l'espace d'état, une trajectoire respective dans ledit espace d'état vers ladite vue cible.
2. Appareil selon la revendication 1, ladite sonde ayant un placement courant, ledit appareil étant configuré pour au moins l'une d'une exposition et d'une instruction sur comment déplacer ladite sonde depuis son placement courant afin de ce fait de parvenir à la réalisation de ladite vue cible (510).
  3. Appareil selon la revendication 1, dans lequel ledit module d'aide à l'utilisateur étant en outre configuré pour détecter une concordance (S244) entre ladite vue cible et la vue reçue.
  4. Appareil selon la revendication 3, configuré pour automatiquement et sans besoin d'une intervention de l'utilisateur, l'un ou l'autre ou les deux de : a) effectuer une notification à l'utilisateur en réponse à ladite détection de ladite concordance ; et b) acquérir des données d'image (S252), par l'intermédiaire de ladite sonde, en réponse à ladite détection de ladite concordance.
  5. Appareil selon la revendication 1, configuré en outre pour présenter une rétroaction (S248) qui instruit, ou montre, comment continuer dans le but de parvenir à la vue cible.
  6. Appareil selon la revendication 1, configuré en outre pour, automatiquement par défaut, initialiser des réglages de Doppler selon ceux qui ont été définis à l'avance pour ladite vue cible en construisant la base de données organisée en tant que dit espace d'état (S404-S464).
  7. Appareil selon la revendication 1, comprenant en outre un scanner (120), configuré pour former ledit espace d'état, ladite formation comprenant :
    - l'acquisition, par l'intermédiaire dudit scanner et à partir de multiples sujets d'imagerie, la pluralité d'images spécialisées pour un organe corporel spécifique, ou un vaisseau, de sorte que ledit organe ou vaisseau, et/ou tissu environnant, est décrit dans la totalité des plusieurs images ; et l'étiquetage des plusieurs images avec les attributs d'image respectifs.
  8. Appareil selon la revendication 7, ladite formation comprenant en outre la liaison (S436), à des images particulières parmi lesdites plusieurs images, d'instructions respectives sur la façon de faire naviguer ladite sonde depuis ladite image particulière à une autre desdites plusieurs images.
  9. Support lisible par ordinateur incorporant un programme informatique pour le guidage dans l'acquisition d'imagerie par ultrasons d'un sujet pour parvenir à une vue cible, ledit programme ayant des instructions exécutables par un processeur pour effectuer une pluralité d'actes, parmi lesquels lesdits actes étant les actes consistant à :
    - émettre des ultrasons vers ledit sujet ;
    - en réponse, recevoir, par l'intermédiaire d'une sonde d'imagerie, une vue courante par ultrasons ;
    - faire concorder la vue reçue à une image préexistante (503), ladite image préexistante étant l'une d'une pluralité d'images d'un organe ou d'un vaisseau d'intérêt et/ou d'un tissu environnant provenant de multiples sujets d'imagerie, pluralité d'images dans laquelle chaque image est étiquetée avec des attributs d'image incluant une anatomie d'image observée, une qualité d'image et une position de sonde et une orientation sur une anatomie superficielle, et laquelle pluralité d'images est comprise dans une base de données statistiques qui est organisée comme un espace d'état ;
    - l'évaluation d'un emplacement de ladite vue reçue dans l'espace d'état, dans lequel des dimensions de chaque point à l'intérieur dudit espace d'état correspondent aux attributs d'image ; et
    - sur la base de ladite concordance, la production d'une rétroaction pour ledit guidage en sélectionnant, sur la base de ladite vue courante par ultrasons et de sa localisation dans l'espace d'état, une trajectoire respective dans ledit espace d'état vers ladite vue cible.

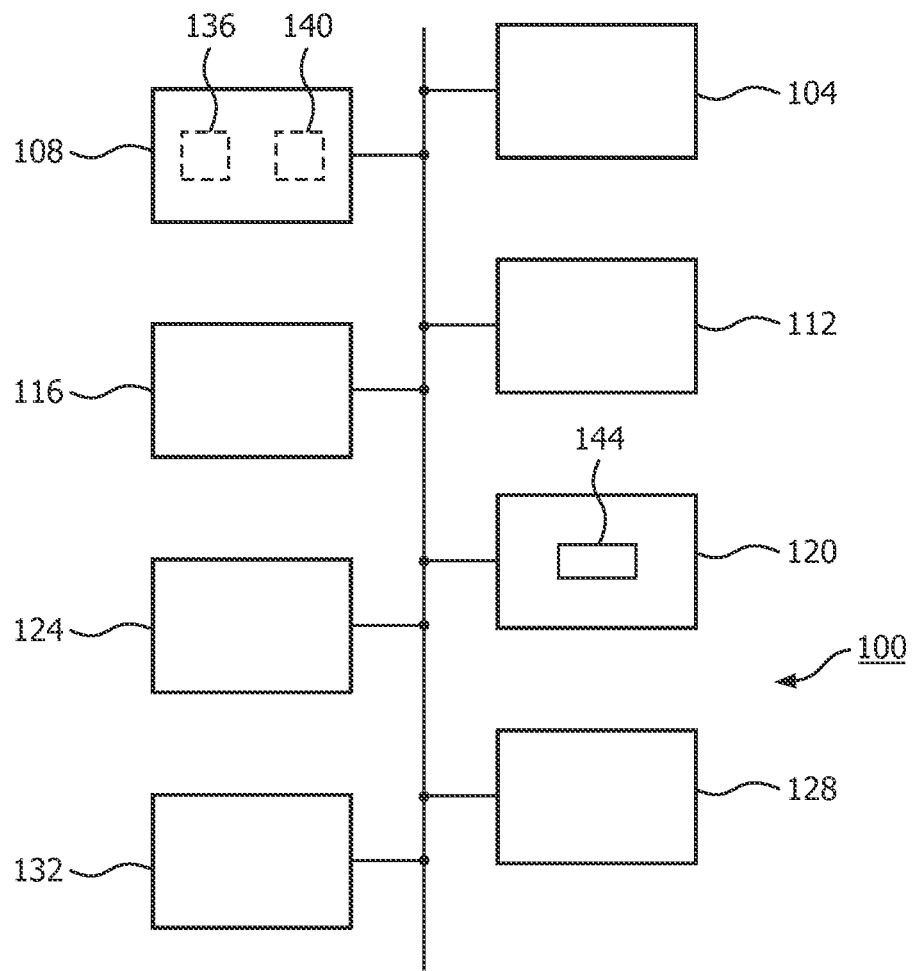


FIG. 1

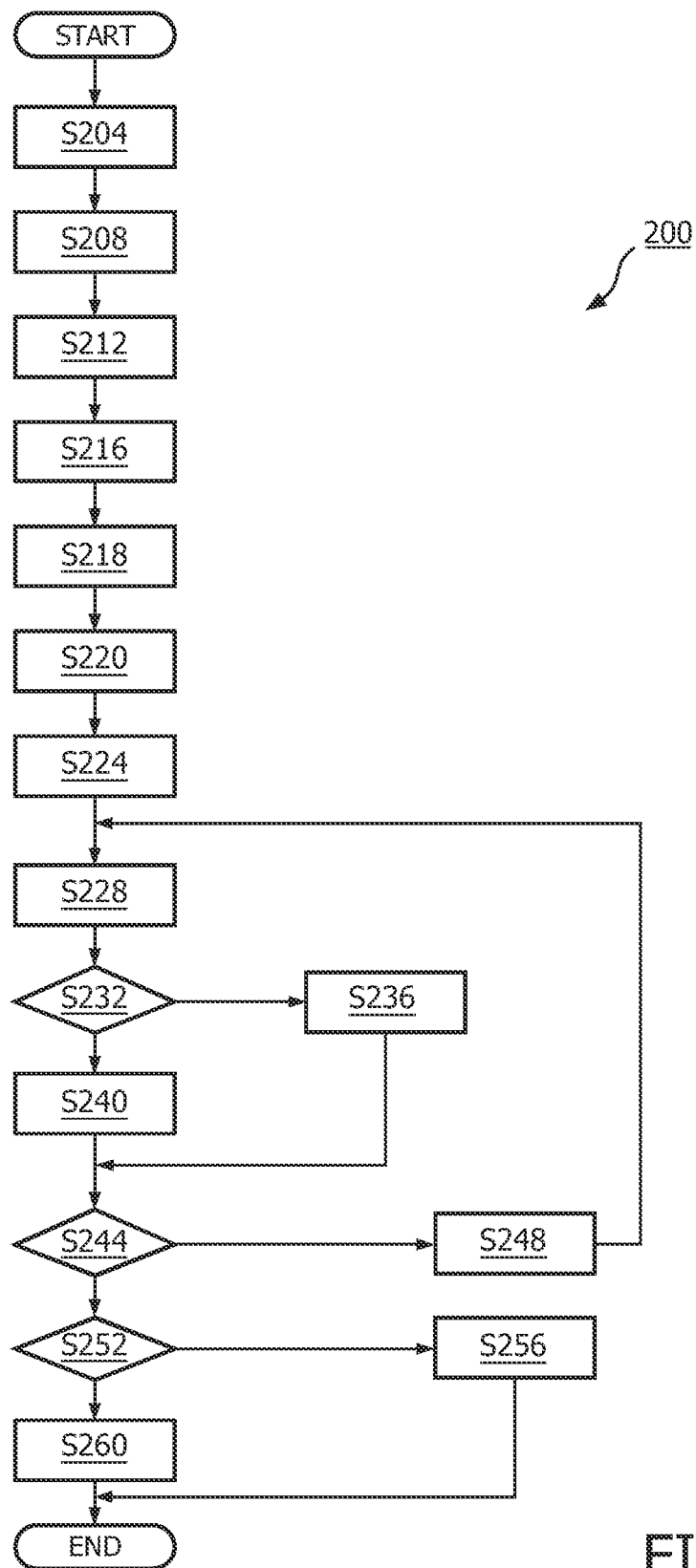


FIG. 2

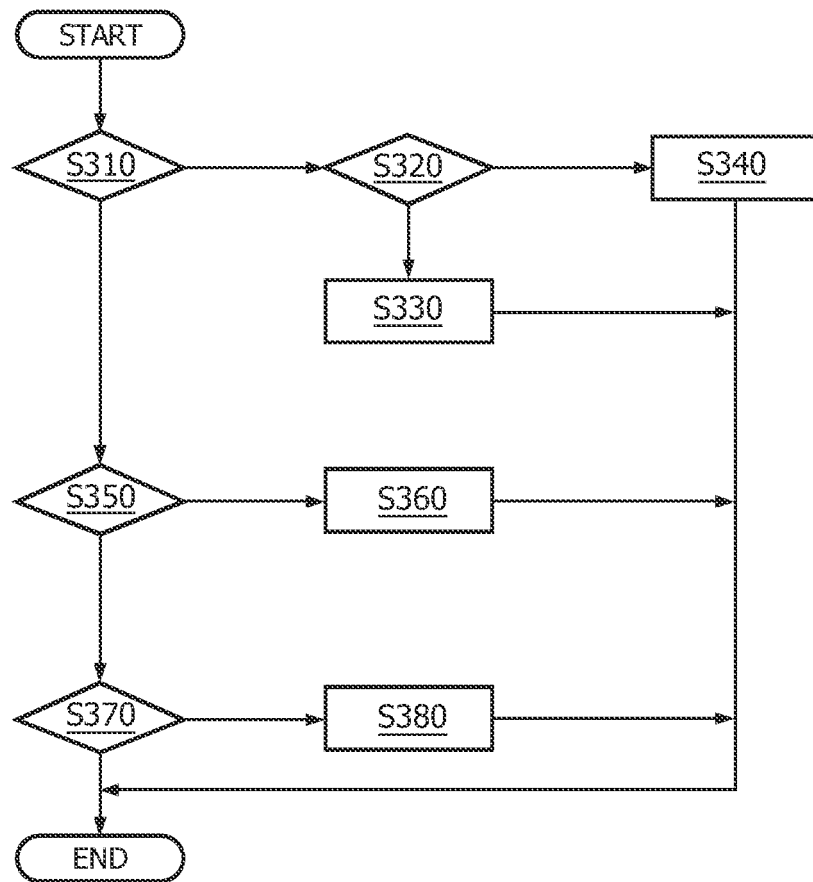


FIG. 3

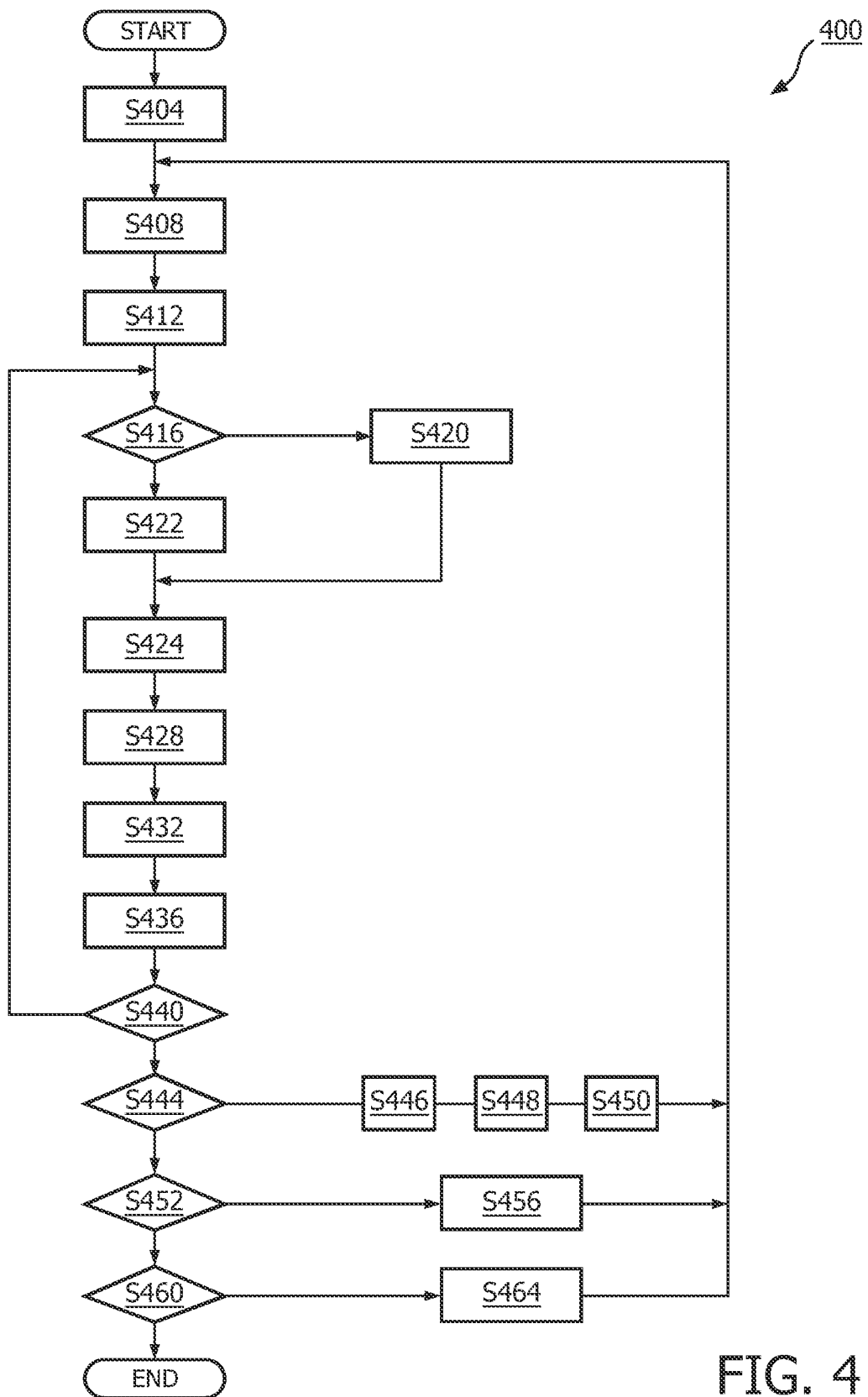
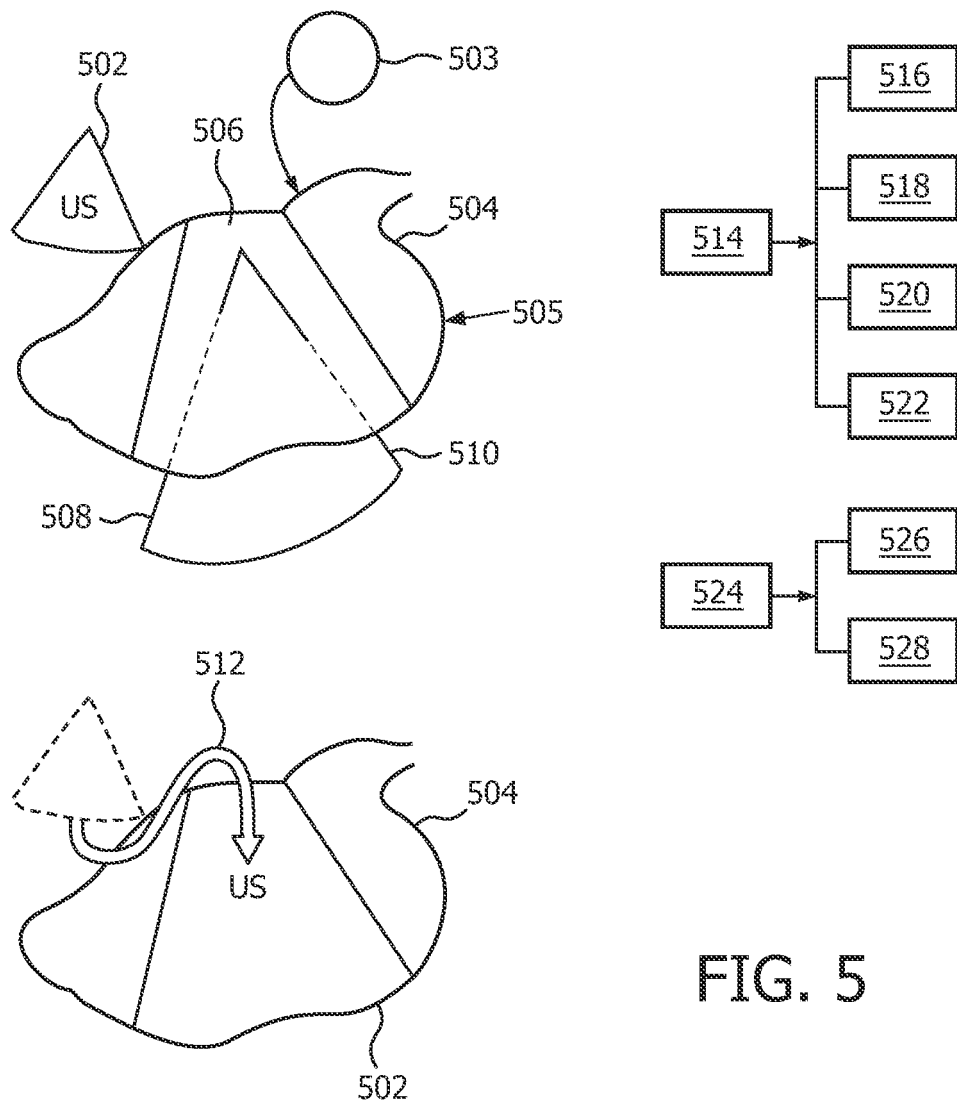


FIG. 4



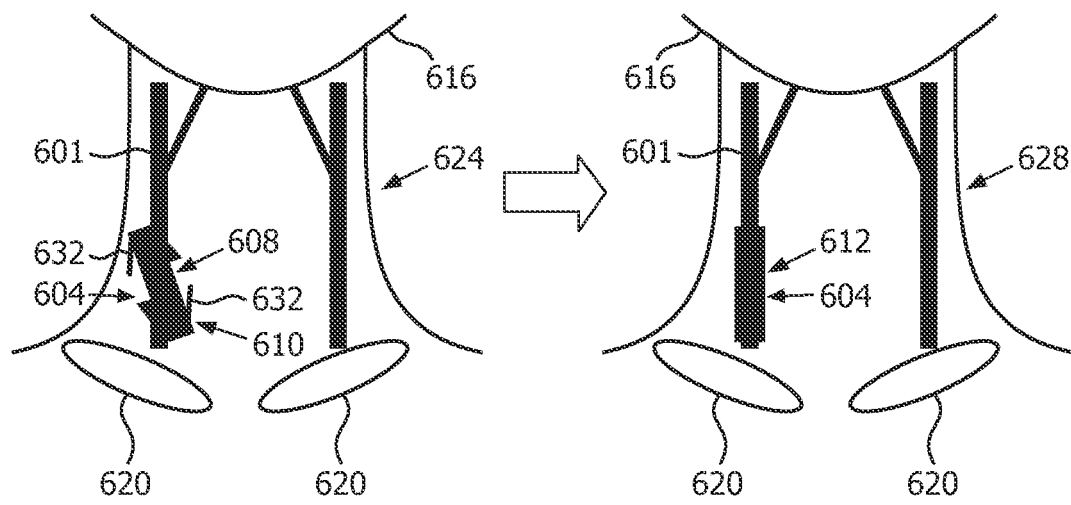


FIG. 6

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- US 20120065510 A, Snare, S. R. [0004]

**Non-patent literature cited in the description**

- **SNARE, S. R. et al.** Real-Time Scan Assistant for Echocardiography. *IEEE Transactions in Ultrasonics, Ferroelectrics, and Frequency Control*, 2012 [0003]

|                |                                                                                               |         |            |
|----------------|-----------------------------------------------------------------------------------------------|---------|------------|
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| 优先权            | 61/840727 2013-06-28 US                                                                       |         |            |
| 其他公开文献         | EP3013242A1                                                                                   |         |            |
| 外部链接           | <a href="#">Espacenet</a>                                                                     |         |            |

#### 摘要(译)

获取对象的超声成像以获得目标视图（例如标准视图）的指导需要向对象发射超声并且作为响应接收当前超声视图（502）；将接收的图像与预先存在的图像匹配，例如三维参考图像（503）；并且，对于用户辅助，基于匹配，生成用于指导的反馈（514-528）。参考图像可以是统计图谱，或者可以源自患者特异性CT或MR扫描。相反，预先存在的图像可以是与状态空间中的状态相对应的数据库图像。反馈可以是参考图像导出的图像；目标视图的平面的图形指示（508）；接收的视图融合（512）到从参考图像导出的图像；或者，所接收的视图和从所述参考图像导出的图像，所导出的图像同时出现并且被增强以在空间上指示所接收的视图在何处登记到参考图像。目标视图（510）可以是受试者的身体器官或血管的视图。地图集和数据库都可以专门用于器官或血管及其周围组织的成像。

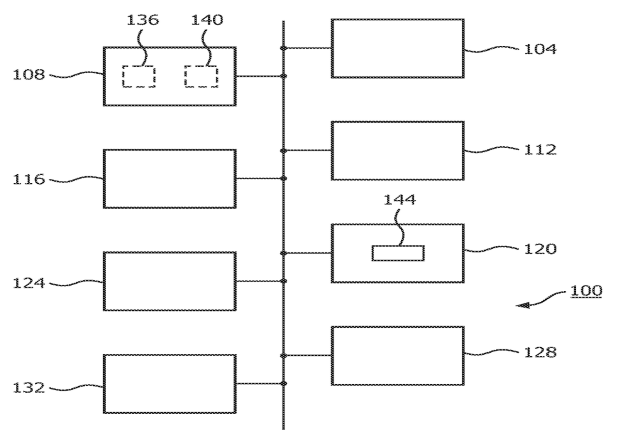


FIG. 1