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(54) **METHOD AND APPARATUS FOR ORGANIC SPECIMEN FEATURE IDENTIFICATION IN ULTRASOUND IMAGE**

(57) An apparatus [100], method [900], and non-transitory computer-readable medium [125]. The apparatus [100] includes a processor [130] configured for receiving ultrasound data [187] from ultrasound reflected waves [202], obtaining anatomic model data [186] corresponding to at least part [155] of the organic specimen [160], and identifying a reference model image region [520a] in the anatomic model data [186] and a corresponding reference propagation region [220a] in the organic specimen [160] using paired equivalent specimen features [210] in the anatomic model data [186] and in the ultrasound data [187]. The ultrasound reflected waves [202] result from reflections of ultrasound incident waves [201] by specimen features [210] in an organic specimen [160]. Positional awareness of each ultrasound reflected wave [202] relative to the organic specimen [160] is maintained.

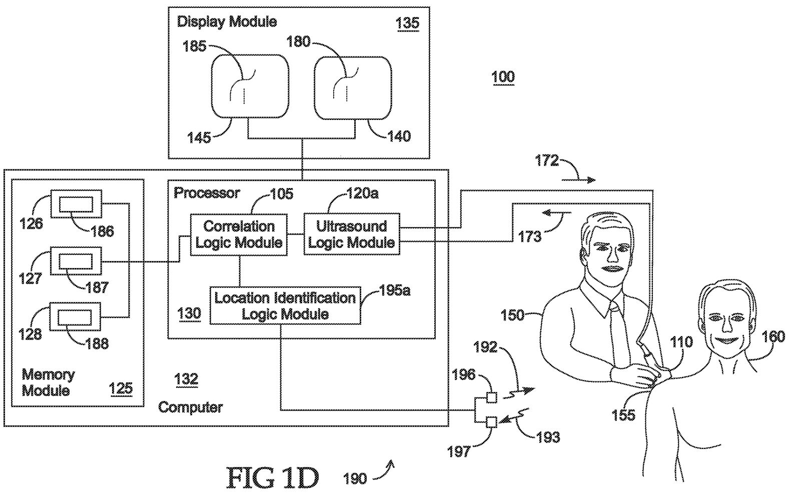

FIG 1D

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Description

BACKGROUND

[0001] Ultrasonic waves are used in various cleaning applications, in medical diagnostic and therapeutic applications, and for a number of research and investigative purposes. Ultrasound has become a widely used, medical diagnostic tool and is generally considered to be safe as well as non- invasive. One of the more well known medical applications is in the creation of visual images of fetuses in the human womb for diagnostic purposes. In other medical areas, however, ultrasound is now used as a diagnostic tool in the creation of visual images of muscles, tendons, and various internal organs. In such applications, the size, structure, and pathological lesions of bodily soft tissues can be captured via real time tomographic images.

[0002] Compared with other diagnostic technologies, such as magnetic resonance imaging (MRI) and computed tomography (CT), ultrasound machines are relatively inexpensive and portable. While X-rays are useful for medical purposes in obtaining images of bones, ultrasonic waves find their medical applications in the creation of soft tissue images. An advantage of ultrasonic waves is that they do not have the negative biological effects associated with X-rays or with other techniques involving radioactive materials.

SUMMARY

[0003] In a representative embodiment, a method is disclosed. The method includes obtaining anatomic model data corresponding to at least part of an organic specimen; specifying a reference model image region in the anatomic model data; transmitting ultrasound incident waves into the organic specimen and receiving thereby ultrasound data from ultrasound reflected waves from specimen features in the organic specimen, wherein positional awareness of each ultrasound reflected wave relative to the organic specimen is maintained; and identifying a reference propagation region corresponding to the reference model image region using paired equivalent specimen features in the ultrasound data and in the anatomic model data.

[0004] In another representative embodiment, a non-transitory computer-readable medium is disclosed. The non-transitory computer-readable medium has computer-executable instructions for causing a computer which includes a processor and associated memory to carry out a method. The method includes obtaining anatomic model data corresponding to at least part of an organic specimen; specifying a reference model image region in the anatomic model data; instructing an ultrasound transducer to transmit ultrasound incident waves into the organic specimen and receiving thereby ultrasound data from ultrasound reflected waves from specimen features in the organic specimen, wherein positional awareness of each ultrasound reflected wave relative to the organic specimen is maintained; and identifying a reference propagation region corresponding to the reference model image region using paired equivalent specimen features in the ultrasound data and in the anatomic model data.

[0005] In yet another representative embodiment, a method is disclosed. The method includes transmitting ultrasound incident waves into an organic specimen and receiving thereby ultrasound data from resultant ultrasound reflected waves from specimen features in the organic specimen, wherein positional awareness of each ultrasound reflected wave relative to the organic specimen is maintained; obtaining anatomic model data corresponding to at least part of the organic specimen; and identifying a reference model image region in the anatomic model data and a corresponding reference propagation region in the organic specimen using paired equivalent specimen features in the anatomic model data and in the ultrasound data.

[0006] In still another representative embodiment, a non-transitory computer-readable medium is disclosed. The non-transitory computer-readable medium has computer-executable instructions for causing a computer which includes a processor and associated memory to carry out a method. The method includes transmitting ultrasound incident waves into an organic specimen and receiving thereby ultrasound data from resultant ultrasound reflected waves from specimen features in the organic specimen, wherein positional awareness of each ultrasound reflected wave relative to the organic specimen is maintained; obtaining anatomic model data corresponding to at least part of the organic specimen; and identifying a reference model image region in the anatomic model data and a corresponding reference propagation region in the organic specimen using paired equivalent specimen features in the anatomic model data and in the ultrasound data.

[0007] In yet still another representative embodiment, an apparatus is disclosed. The apparatus includes a processor configured for receiving ultrasound data from ultrasound reflected waves, wherein the ultrasound reflected waves result from reflections of ultrasound incident waves by specimen features in an organic specimen and wherein positional awareness of each ultrasound reflected wave relative to the organic specimen is maintained; obtaining anatomic model data corresponding to at least part of the organic specimen; and identifying a reference model image region in the anatomic model data and a corresponding reference propagation region in the organic specimen using paired equivalent specimen features in the anatomic model data and in the ultrasound data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The accompanying drawings provide visual representations which will be used to more fully describe various representative embodiments disclosed herein.

They can be used by those skilled in the art to better understand the representative embodiments. In these drawings, like reference numerals identify corresponding elements.

Figure 1A is a block diagram of an apparatus for identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 1B is a block diagram of another apparatus for identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 1C is a block diagram of still another apparatus for identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 1D is a block diagram of yet another apparatus for identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 1E is a block diagram of yet still another apparatus for identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 2 is a front view of the patient of Figures 1A, IB, and 1C with the ultrasound transducer coupled to the shoulder of the patient.

Figure 3 is a side view of the arrangement whose front view is shown in Figure 2.

Figure 4 is a side view of a modified arrangement of the side view shown in Figure 3.

Figure 5 is a side view of a three-dimensional reconstructed model from the anatomic model data for the arrangement of Figure 4.

Figure 6 is another drawing of the display module of Figures 1A, 1B, and 1C with the ultrasound transducer placed as in Figure 4.

Figure 7 is a drawing of an alternative embodiment of a display module for the apparatuses of Figures 1A, 1B, and 1C.

Figure 8 is a flow chart of a method for the identification of organic specimen features in ultrasound images as described in various representative embodiments.

Figure 9 is a flow chart of another method for the identification of organic specimen features in ultrasound images as described in various representative embodiments.

DETAILED DESCRIPTION

[0009] Novel techniques are disclosed herein of methods and apparatuses for the identification of organic features in ultrasound images of organic specimens as shown in the drawings for purposes of illustration. An organic specimen is any living or deceased organism or a portion of a living or deceased organism. In particular, the organic specimen could be a human, an animal, a mammal, a plant, a portion of a human, a portion of an animal, a portion of a mammal, or a portion of a plant. The human could be a baby, an infant, a child, an adolescent, a teenager, or an adult. The human could be further referred to as the human subject, the animal as the animal subject, the mammal as the mammal subject, and the plant as the plant subject.

[0010] Ultrasound has been used to monitor fetus development in the womb and more recently for diagnosis in musculoskeletal applications. Musculoskeletal applications include the diagnosis of muscle tears, tendon tears such as rotator cuff tears, nerve problems, blood clots in the vascular system, and the like. Musculoskeletal ultrasound images differ from those obtained in monitoring fetus development in the womb in that the musculoskeletal ultrasound transducer transmits its signal in a straight line rather than a curve. As such, a straight tendon will be displayed as a straight line on the ultrasound monitor. Such ultrasound machines are being used more and more in outpatient settings. MRI, as well as ultrasound, can be used to create images of soft, internal body tissues, but MRIs are expensive. Nuclear methods can also be used but are less desirable than ultrasound as they expose the body to radiation. Another advantage of ultrasound is that it can be used to create dynamic pictures rather than the static pictures of MRI. Ultrasound diagnostic devices provide immediate images, are portable, are safe, and are economical.

[0011] However, current ultrasound devices require extensive training to develop the skills necessary for interpreting ultrasound images. Even after extensive training, inaccurate diagnoses are not uncommon, and results are often inconsistent from one operator to another. Correctly identifying a patient's internal features in an ultrasound image has been strongly dependent upon the skill of the operator that is interpreting the image. The greatest barrier to the use of ultrasound is that it must be practiced over and over again which is time consuming and expensive. The operator must be able to correctly identify the tissue displayed in an ultrasound image which means that he/she must also know anatomy in great detail as there are a large number of different parts of the human anatomy that can be detected by ultrasound. The number of operators that have had an acceptable level of this skill has been very limited, and the cost of obtaining this skill has been expensive.

[0012] Conversely, the representative embodiments disclosed herein provide apparatuses and methods that can significantly reduce operator training time and thereby training expense, can reduce the incidence of an inaccurate diagnosis by the correct identification of tissues, and can reduce the variation from operator to operator in a diagnosis.

[0013] While the present invention is susceptible to embodiment in many different forms, there is shown in the drawings and will herein be described in detail one or more specific embodiments, with the understanding that the present disclosure is to be considered as exemplary of the principles of the invention and is not intended to limit the invention to the specific embodiments shown and described. In the following description and in the several figures of the drawings, like reference numerals are used to describe the same, similar, or corresponding parts in the several views of the drawings.

[0014] In representative embodiments, an ultrasound image obtained from an organic specimen under study is correlated with data that represents or models all or part of that organic specimen. By first identifying certain features and anatomic patterns in the organic specimen that are relatively easy to identify and correlating that information with data from the model of the organic specimen, a reference position of an ultrasound transducer with respect to the organic specimen can be identified. Then while maintaining knowledge of any subsequent movement of the ultrasound transducer and/or any subsequent movement of the organic specimen relative to the reference locations of the ultrasound transducer and the organic specimen, subsequent ultrasound images of the organic specimen can be correlated with images created from the model. This correlation enables an operator to relatively easily identify features in the organic specimen on the ultrasound image. A software program could be used to automatically identify such features. To facilitate identification of features of the organic specimen, the ultrasound and model images can be displayed simultaneously either on two separate displays or together on a single display. In alternative embodiments, the two images could be overlaid, and certain features in one or the other images could be differentially colored, displayed with dashes, dots, or otherwise differentiated lines and areas, labeled and/or otherwise appropriately identified. Also, one or the other images could be faded in and out. A computer program could provide texted or auditory identification of a specific tissue upon request. In addition, the operator could preselect particular features of interest to be emphasized when found in an ultrasound image. Such emphasis can also be added by, for example, the addition of a preselected color to the feature of interest, a flashing indicator, displayed with dashes, dots, or otherwise differentiated lines and areas, labels and/or other appropriate means. Movement of the ultrasound transducer could be programmatically controlled so as to locate preselected features on the organic specimen with little or no operator assistance.

[0015] As the ultrasound transducer is moved, the location of the ultrasound transducer relative to its identified, reference location can be maintained by a mechanical fixture attached to the ultrasound transducer, by the detection of targets placed on the ultrasound transducer using mechanical, infrared, optical, radio frequency, inertial means, or by any other acceptable means. The location of the organic specimen relative to the identified, reference location of the ultrasound transducer can be maintained by holding the organic specimen immobilized, by a mechanical fixture attached to a non-moving surface and to the organic specimen, or by the detection of targets placed on the organic specimen using, mechanical coupling, infrared, optical, radio frequency, inertial means, or by any other acceptable means.

[0016] The Visible Human Project® (VHP) is an effort to create a detailed data set from cross-sectional photographs of the human body. The Visible Human Project® is a registered trademark of the National Library of Medicine. To obtain the data, successive layers of a male and a female cadaver were removed by grinding away the top surface at regular intervals. Each of the revealed planar surfaces was photographed and stored electronically. Image data for each pixel in the two-dimensional photographs are stored in digital format along with their associated three-dimensional coordinates. Pixel image and associated coordinate data can be used to create two-dimensional and three-dimensional images of a representative human body (male or female) at diverse selected depths and angular orientations.

[0017] In representative embodiments, anatomic model data which could be, for example, the VHP data are used in combination with ultrasound data and a three-dimensional location detection device to create correlated model and ultrasound images in a human patient as well as other organic entities. These correlated images can be used to facilitate the identification of specific features in the ultrasound images of the human patient or other organic specimen. A location detection unit could use a set of targets coupled to the organic specimen and another set of targets coupled to the ultrasound transducer to acquire the location and orientation of the ultrasound transducer relative to the organic specimen. These targets could be identified and located by mechanical coupling means, optical, infrared, radio frequency, inertial means, or other appropriate techniques or by a combination of such techniques. Once the reference location of the ultrasound transducer relative to the patient (the organic specimen) is set, the location detection unit monitors any subsequent motion of the ultrasound transducer and/or the patient, identifies the related subsequent location of the ultrasound transducer and patient, and identifies, thereby, the location and orientation of the ultrasound image and the associated model image. A split screen, dual screen, or other appropriate display module can be used to view the ultrasound and model images obtained. By correlating the ultrasound and model images and by identifying features on the model image by some means which could be, for example, by the use of tags, features on the ultrasound image can be readily identified by an operator. Using such embodiments, it is no longer necessary for the operator to receive the extensive training that has previously been required. Previously several years of expensive training typically have been needed for an operator to attain the needed skill level.

[0018] Due to the large amount of data that can be associated with any given model, it may be advantageous to divide the model into different specific areas of interest such as, for example, a shoulder, an elbow, a wrist, a hip, or other specific body part. Once the operator identifies a known feature of the patient, which could be, for example, the small notch in the bones of a shoulder in which the bicep tendon passes through or other readily identifiable feature, the operator could push a button or click a mouse button to select that feature as one used for setting a plane of reference. Once the reference frame is selected, the operator could select a feature on the ultrasound image by a mouse click or other means and a program could then identify that feature and notify the operator of its identity. In representative embodiments, apparatuses and methods disclosed herein could be used as a diagnostic tool and/or as a teaching tool.

[0019] Pathology in the anatomic model data could be digitally repaired so that the model is in pristine condition prior to its use with ultrasound images. The human anatomic model data might have, for example, a rotator cuff tear or other damage. Repairing this tear in the anatomic model data would facilitate detecting similar damage in the patient. Based on the distances between features in the ultrasound image used to set the reference location of the ultrasound transducer relative to the patient (the organic specimen), the model image can be appropriately scaled to match the size of the patient. Alternatively, the anatomic model data could have previously been scaled to certain preset representative patient sizes such as, for example, small, medium, and large and adjusted to known anatomic variants.

[0020] While the representative embodiments disclosed herein are discussed in terms of static two-dimensional model and ultrasound images, the representative embodiments can also be implemented using time varying two-dimensional model and ultrasound images, static three-dimensional model and ultrasound images, and time varying three-dimensional model and ultrasound images. As appropriate, these images can be displayed on a two-dimensional display as static or time varying two-dimensional images and on a three-dimensional display as static or time varying three-dimensional images.

[0021] Figure 1A is a block diagram of an apparatus 100 for identification of organic specimen 160 features in ultrasound images 180 as described in various representative embodiments. The apparatus 100 comprises an ultrasound transducer 110, an ultrasound controller 120, a display module 135, a location detection unit 190, and a computer 132. The computer 132 comprises a memory module 125 and a processor 130. In Figure 1A, the display module 135 comprises an ultrasound display 140 also referred to herein as a first display 140 and a model display 145 also referred to herein as a second display 145. The memory module 125 comprises an anatomic model memory 126, an ultrasound memory 127, and an extracted model memory 128. The location detection unit 190 comprises an emitter device 196, a receptor device 197, and a location identification module 195.

[0022] The ultrasound transducer 110 is separately coupled to the ultrasound controller 120 and to the processor 130. The processor 130 is also coupled to the location detection unit 190 which transfers information regarding the relative locations of the ultrasound transducer 110 and the organic specimen 160 via location data 194 to the processor 130, to the memory module 125 within which the processor 130 is coupled to the anatomic model memory 126, the ultrasound memory 127, and the extracted model memory 128, to the display module 135 within which the processor 130 is coupled to the ultrasound display 140 and the model display 145, and to the ultrasound controller 120. Coupling between the various components of the apparatus 100 could be via electronic cables, optical fibers, pairs of radio frequencies or infrared transmitter/receivers, or other appropriate means for transmitting or transferring signals.

[0023] The ultrasound memory 127 is configured to store sets of ultrasound data 187 obtained from the ultrasound transducer 110. The anatomic model memory 126 is configured to store anatomic model data 186 which is a model of and representative of at least part 155 of an organic specimen 160. The extracted model memory 128 is configured to store sets of model extracted data 188. In representative embodiments, a set of model extracted data 188 can be obtained from the anatomic model data 186 for each set of ultrasound data 187 and can be associated with each set of ultrasound data 187. Each associated set of ultrasound data 187 and model extracted data 188 can be used to create associated ultrasound and model images 180,185 wherein the model image 185 is a model of the region from which the ultrasound image 180 is obtained. The processor 130 is configured to obtain the appropriate set of model extracted data 188 and correlate it with its associated set of ultrasound data 187. In an alternate representative embodiment, the model image 185 can be created from the set of model extracted data 188 without storage of the model extracted data 188. And in another alternate representative embodiment, the set of ultrasound data 187 and the set of model extracted data 188 are stored jointly in a single memory which could be the ultrasound memory 127. The ultrasound image 180 can be displayed on the ultrasound display 140, and concurrently the model image 185 associated with the ultrasound image 180 can be displayed on the model display 145.

[0024] The location identification module 195 is configured to instruct the emitter device 196 to transmit location interrogation signals 192 to transducer targets 230 (see Figure 2 and discussion therewith) on the ultrasound transducer 110 and to specimen targets 240 (see Figure 2 and discussion therewith) on an organic specimen 160 which could be a patient 160. Upon reception of the location interrogation signals 192 by the transducer targets 230 and the specimen targets 240, the transducer targets 230 and the specimen targets 240 separately respond with location information signals 193 which can be received by the receptor device 197. Information from the location information signals 193 received by the receptor device 197 is transferred from the receptor device 197 to the location identification module 195. The location identification module 195 is further configured to extract location information for the transducer targets 230 and the specimen targets 240 from the information in the location information signals 193 and/or from the location interrogation signals 192. The extracted location information for the transducer targets 230 and the specimen targets 240 is transferred to the processor 130 as location data 194. The location data 194 can be used by the processor 130 to associate a specific set of ultrasound data 187 with the relative locations and orientations of the ultrasound transducer 110 and the organic specimen 160 for which that set of ultrasound data 187 was obtained. The location data 194 can also be used by the processor 130 to obtain a set of model extracted data 188 from the anatomic model data 186 for the region from which the set of ultrasound data 187 is obtained. This set of model extracted data 188 is thereby associated with that set of ultrasound data 187.

[0025] In representative embodiments, an operator 150 holds the ultrasound transducer 110 against, for example, a shoulder 155 of a patient 160. The patient 160 shown in Figure 1A could more generally be any organic specimen 160 and more particularly could be a person 160, a baby 160, another animal 160, a plant 160 or the like. However, the term organic specimen 160 as used herein more generally means any living or deceased organism or any portion of a living or deceased organism. In particular, the organic specimen could be a human, another animal, a plant, a portion of a human, a portion of another animal, or a portion of a plant. The shoulder 155 shown in Figure 1A could more generally be a part 155 of any organic specimen 160. The initiation signal 171, the activation signal 172 and reflected data signal 173 will be more completely described with the description of Figure 2. The anatomic model data 186 stored in the memory module 125 could be anatomic model data 186 of at least part 155 of the organic specimen 160. In representative embodiments, the anatomic model data 186 could be obtained, for example, from the Visible Human Project® (VHP) or other appropriate data which can be used, for example, to create two-dimensional model images 185 of a representative human body (male or female) at diverse selected depths and angular orientations. The VHP data and other model data sources could be used to create static two-dimensional, static three-dimensional, time varying two-dimensional, and/or time varying three-dimensional model images 185. Various components of Figure 1A will be more completely described with the description of subsequent figures.

[0026] While the representative embodiments disclosed herein are discussed in terms of static two-dimensional model and ultrasound images 185,180, the representative embodiments can also be implemented using time varying two-dimensional model and ultrasound images 185,180, static three-dimensional model and ultrasound images 185,180, and time varying three-dimensional model and ultrasound images 185,180. As appropriate, these images can be displayed, for example, on a two-dimensional display as static or time varying two-dimensional images and on a three-dimensional display as static or time varying three-dimensional images.

[0027] Figure 1B is a block diagram of another apparatus 100 for identification of organic specimen 160 features in ultrasound images 180 as described in various representative embodiments. The apparatus 100 of Figure 1B differs from that of Figure 1A by the inclusion of the functions of the ultrasound controller 120 in the processor 130. In this embodiment, the processor 130 comprises the ultrasound controller 120 which creates the activation signal 172 directly and then transfers the activation signal 172 to the ultrasound transducer 110. Again, the activation signal 172 and the reflected data signal 173 will be more completely described with the description of Figure 2, and various other components of Figure 1B will be more completely described with the description of subsequent figures.

[0028] Figure 1C is a block diagram of still another apparatus 100 for identification of organic specimen 160 features in ultrasound images 180 as described in various representative embodiments. The apparatus 100 of Figure 1C differs from that of Figure 1A in that the ultrasound controller 120 receives the reflected data signal 173 from the ultrasound transducer 110 and then transfers the reflected data signal 173 to the processor 130 either as received or as appropriately modified. The apparatus 100 of Figure 1C also differs from that of Figure 1A in that the functions of the location identification module 195 are included in the processor 130 with the emitter device 196 and the receptor device 197 located external to the processor 130. The location detection unit 190 comprises the emitter device 196, the receptor device 197, and the location identification module 195. Again, the activation signal 172 and the reflected data signal 173 will be more completely described with the description of Figure 2, and various other components of Figure 1C will be more completely described with the description of subsequent figures.

[0029] In alternative embodiments, the location detection unit 190 of Figure 1A could replace the location detection unit 190 of Figure 1C in the configuration of Figure 1C, the location detection unit 190 of Figure 1C could replace the location detection unit 190 of Figure 1A in the configuration of Figure 1A, and the location detection unit 190 of Figure 1C could replace the location detection unit 190 of Figure IB in the configuration of Figure 1B.

[0030] Figure 1D is a block diagram of yet another apparatus 100 for identification of organic specimen 160 features in ultrasound images 180 as described in various representative embodiments. The apparatus 100 of Figure 1D differs from that of Figure 1A in that the processor 130 comprises an ultrasound logic module 120a, a location identification logic module 195a, and a correlation logic module 105.

[0031] The ultrasound logic module 120a can be configured to perform the functions associated with the ultrasound controller 120 of Figures 1A, 1B, and/or 1C and is operatively coupled to the ultrasound transducer 110 and to the correlation logic module 105. upon instructions from the processor 130, the ultrasound logic module 120a initiates transmission of the activation signal 172 to the ultrasound transducer 110 and receives the subsequent reflected data signal 173. The ultrasound logic module 120a then transfers ultrasound data 187 from the reflected data signal 173 to the correlation logic module 105.

[0032] Figure 1E is a block diagram of yet still another apparatus 100 for identification of organic specimen features in ultrasound images as described in various representative embodiments. The apparatus 100 of Figure 1E differs from that of Figure 1D in that the processor 130 comprises a computer program 133 which is also referred to herein as a computer program product 133.

[0033] The computer program product 133 comprises instructions for carrying out a method 900 when executed by the processor 130 on the computer 132. The computer program product 133 is stored on a computer readable storage medium which could be the memory module 125 and/or the memory of the processor 130. The computer readable storage medium could be the hard drive of a computer, a floppy disk, a CD, a DVD, a RAM memory, or other acceptable storage medium. In a representative embodiment, the computer program product 133 comprises an ultrasound logic module 120a, a location identification logic module 195a, and a correlation logic module 105. These logic modules comprise instructions for performing a method 900, wherein the method 900 comprises: specifying a reference model image region 520a in model extracted data 188 obtained from anatomic model data 186 of at least part 155 of an organic specimen 160; instructing an ultrasound transducer 110 to transmit ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness 194 of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; identifying a reference propagation region 220a corresponding to the reference model image region 520a from paired recognized specimen features 210 in the ultrasound data 202 and in the model extracted data 188; instructing the ultrasound transducer 110 to transmit at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and the propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180, creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187, and instructing a display module 135 to display the ultrasound image 180 and the model image 185.

[0034] The location identification logic module 195a is configured to instruct the emitter device 196 to transmit location interrogation signals 192 to transducer targets 230 (see Figure 2 and discussion therewith) on the ultrasound transducer 110 and to specimen targets 240 (see Figure 2 and discussion therewith) on an organic specimen 160 which could be a patient 160 and to receive location information from subsequent location information signals 193 received by the receptor device 197. The location identification logic module 195a is further configured to extract location information for the transducer targets 230 and/or the specimen targets 240 from the information in the location information signals 193 and/or from the location interrogation signals 192. This location information is then transferred to the correlation logic module 105. In Figure ID, the location detection unit 190 comprises the emitter device 196, the receptor device 197, and the location identification logic module 195a.

[0035] The correlation logic module 105 is configured to receive ultrasound data 187 from the ultrasound logic module 120a and location information from the location identification logic module 195a, to obtain model extracted data 188 from the anatomic model data 186 in the memory module 125, to identify a reference model image plane 520a in the model extracted data 188, to identify a corresponding reference propagation plane 220a from recognized specimen features 210 in the ultrasound data 187 and associated location information from the location identification logic module 195a, to receive ultrasound data 187 from subsequent ultrasound reflected waves 202 from one or more specimen features 210 wherein positional awareness is maintained between the reference propagation plane 220a and the propagation plane 220 of the subsequent ultrasound data 187, and for the subsequent ultrasound data 187 to create an ultrasound image 180, to create a model image 185 for a model image plane 520 from the anatomic model data 186 corresponding to the propagation plane 220 of the subsequent ultrasound data 187, and to transfer the ultrasound image 180 and the model image 185 to the display module 135. As appropriate, the correlation logic module 105 can be further configured to store the ultrasound data 187, the model extracted data 188, the ultrasound images 180, and/or the model images 185.

[0036] In alternative representative embodiments, the ultrasound logic module 120a, the location identification logic module 195a, and/or the correlation logic module 105 can be implemented in hardware, as a software program, or in firmware either external to or internal to the processor 130. The software program and/or the firmware could be configured to provide instructions to the computer 105 to perform various method steps and/or functions disclosed herein. In other alternative embodiments, the ultrasound logic module 120a, the location identification logic module 195a, and/or the correlation logic module 105 can be replaced respectively by the ultrasound controller 120, the location identification module 195, and or the functions of the processor 130 as in the configurations of Figures 1A, 1B, and/or 1C.

[0037] Figure 2 is a front view of the patient 160 of Figures 1A, 1B, and 1C with the ultrasound transducer 110 coupled to the shoulder 155 of the patient 160. In the embodiment of Figure 2, the activation signal 172 is transferred to the ultrasound transducer 110 which converts it to an ultrasound incident wave 201 and then transmits the ultrasound incident wave 201 into the shoulder 155 of the patient 160 in a propagation plane 220. The propagation plane 220 is considered in an ideal sense to extend to infinity in two dimensions. However, only that part of the propagation plane 220 into which the ultrasound incident wave 201 is transmitted is shown in Figure 2. The ultrasound incident wave 201 is reflected by various specimen features 210, as well as patient unique features 450 (see Figure 4 and discussion therewith) which are also referred to herein as organic specimen unique features 450, in the patient's shoulder 155 as ultrasound reflected waves 202. A patient unique feature 450 could be a pathologic feature 450 such as a muscle tear, a tendon tear such as a rotator cuff tear, a nerve problem, a blood clot in the vascular system, or the like, or it could be a foreign object 450 such as a metallic pin affixed to a broken bone in the patient 160 or the like. The ultrasound reflected waves 202 are detected by the ultrasound transducer 110 and converted into a reflected data signal 173 which is in turn transferred back to the processor 130. The plane of the ultrasound image 180 created from the reflected data signal 173 is from features in the propagation plane 220 and, thus, the propagation plane 220 is also the plane of the ultrasound image 180 and is also referred to as the ultrasound image plane 220.

[0038] The three specimen features 210a,210b,210c (first specimen feature 210a, second specimen feature 210b, and third specimen feature 210c) separately reflect that part of the ultrasound incident wave 201 incident on them as associated ultrasound reflected waves 202a,202b,202c (first ultrasound reflected wave 202a, second ultrasound reflected wave 202b, and third ultrasound reflected wave 202c). In the representative embodiment of Figure 2, these three specimen features 210a,210b,210c have separately identifiable specimen reference points 215 (first specimen reference point 215a, second specimen reference point 215b, and third specimen reference point 215c) that together specify a reference propagation plane 220a which is used for specifying the location of and identification of additional, detected specimen features 210. The three specimen features 210a, 210b, 210c and their associated specimen reference points 215a, 215b, 215c in the representative embodiment of Figure 2 are shown for illustrative purposes only and are not intended to represent any physical feature of the shoulder 155 or any other part 155 of the patient 160.

[0039] In locating the specimen reference points 215a,215b,215c which are typically selected previously for locating, the operator 150 moves the ultrasound transducer 110 to different locations on the shoulder 155 of the patient 160 until the three specimen reference points 215a,215b,215c are found. For ease of illustration and discussion, all three specimen reference points 215a,215b ,215c are shown in Figure 2 as being detected with the ultrasound transducer 110 in a single location, i.e., with the three specimen reference points 215a,215b ,215c in a single reference propagation plane 220a. In the more general case, however, as long as current locations of the ultrasound transducer 110 are known relative to a previous location, detection of the three specimen reference points 215a, 215b, 215c in separate propagation planes 220, i.e., with the ultrasound transducer 110 in separate locations relative to the patient 160 can be used to specify the reference propagation plane 220a.

[0040] Also shown in Figure 2 are three transducer targets 230 (first transducer target 230a, second transducer target 230b, and third transducer target 230c) and three specimen targets 240 (first specimen target 240a, second specimen target 240b, and third specimen target 240c). In representative embodiments, the emitter device 196 of the location detection unit 190 transmits one or more location interrogation signals 192 which are received by the transducer targets 230 and the specimen targets 240. In response to the location interrogation signals 192, the transducer targets 230 and the specimen targets 240 return location information signals 193 which are received by the receptor device 197. The location identification module 195 monitors any movement of the ultrasound transducer 110 and of the patient 160. The location identification module 195 transfers information regarding the locations of the ultrasound transducer 110 and the organic specimen 160 via location data 194 to the processor 130. The transducer and specimen targets 230,240 could transmit location information signals 193 in response to location interrogation signals 192, actively transmit location information signals 193 automatically without initiation from the location interrogation signals 192, or passively reflect the location interrogation signals 192 as location information signals 193. The location interrogation signals 192 and location information signals 193 could be infrared, optical, radio frequency or any other acceptable signal types. In addition, information regarding the relative locations of the ultrasound transducer 110 and the organic specimen 160 can be maintained as the ultrasound transducer 110 and/or the organic specimen 160 are/is moved by a mechanical fixture (see Figure 3) attached to the ultrasound transducer 110 or by an inertial reference device (see Figure 4) attached to the ultrasound transducer 110.

[0041] Figure 3 is a side view of the arrangement whose front view is shown in Figure 2. As indicated in the discussion of Figure 2, the three specimen features 210a,210b,210c separately reflect that part of the ultrasound incident wave 201 incident on them as associated ultrasound reflected waves 202a,202b,202c (first ultrasound reflected wave 202a, second ultrasound reflected wave 202b, and third ultrasound reflected wave 202c). In the representative embodiment of Figures 2 and 3, these three specimen features 210a,210b,210c have separately identifiable specimen reference points 215a,215b,215c that together specify a reference propagation plane 220a that will be used for specifying the location of and identification of additional, detected specimen features 210. The reference propagation plane 220a of the ultrasound incident wave 201 is shown edge on in Figure 3 and therefore appears as a line in that figure. As previously indicated, all three specimen reference points 215a, 215b, 215c may be detected with the ultrasound transducer 110 in a single location as shown in Figures 2 and 3. However, as long as any current location of the ultrasound transducer 110 is known relative to a previous location, the three specimen reference points 215a, 215b, 215c can be detected in separate propagation planes 220, i.e., with the ultrasound transducer 110 in separate locations.

[0042] Also, shown in Figure 3 is a representative embodiment wherein the emitter device 196 and the receptor device 197 of the location detection unit 190 are replaced by a mechanical coupling device 310 which can be used to maintain a reference between the location of the ultrasound transducer 110 and the location of the patient 160. The mechanical coupling device 310 comprises a mechanical fixture 320 and a mechanical coupler 330. In order to reduce or eliminate movement by the patient 160, the mechanical fixture 320 is placed adjacent to the patient 160. The mechanical coupler 330 is located between the mechanical fixture 320 and the ultrasound transducer 110. Measurements of various angular rotations of components in the mechanical coupling device 310 relative to the reference propagation plane 220a can be used to compute the new propagation plane 220 following any movement of the ultrasound transducer 110.

[0043] Figure 4 is a side view of a modified arrangement of the side view shown in Figure 3. In Figure 4, the ultrasound transducer 110 is again coupled to the shoulder 155 of the patient 160. However, the ultrasound transducer 110 has been moved to another location on the shoulder 155 of the patient 160.

[0044] Also, shown in Figure 4 is a representative embodiment wherein the emitter device 196 and the receptor device 197 of the location detection unit 190 of Figures 1A, 1B, and 1C are replaced by an inertial reference device 410 which can be used to maintain a reference between the location of the ultrasound transducer 110 and the location of the patient 160. The inertial reference device 410 comprises a first inertial module 420 and a second inertial module 430. The first inertial module 420 is coupled to the ultrasound transducer 110 and a second inertial module 430 is coupled to the patient 160. Communication between the first and the second inertial modules 420,430 and the processor 130 can be effected by infrared, optical, radio frequency, or any other acceptable communication technology. A combination of the mechanical fixture 320 in Figure 3 coupled to the patient 160 and the first inertial module 420 coupled to the ultrasound transducer 110 can also be used to maintain information regarding the location of the ultrasound transducer 110 relative to the patient 160.

[0045] As previously discussed, the ultrasound transducer 110 converts the activation signal 172 to an ultrasound incident wave 201 and transmits it into the shoulder 155 of the patient 160 in the propagation plane 220. The ultrasound incident wave 201 in Figure 4 is reflected in the patient's shoulder 155 by two additional specimen features 210d, 210e (fourth specimen feature 210d and fifth specimen feature 210e) and the patient unique feature 450 as additional ultrasound reflected waves 202d,202e,202f (fourth ultrasound reflected wave 202d, fifth ultrasound reflected wave 202e, and sixth ultrasound reflected wave 202f). The ultrasound reflected waves 202d,202e,202f are detected by the ultrasound transducer 110 and converted into the reflected data signal 173. However, the three specimen features 210a,210b,210c and their associated specimen reference points 215a,215b,215c are not detectable by the ultrasound transducer 110 with the ultrasound transducer 110 positioned as in Figure 4 as these specimen features 210a,210b,210c do not lie in the current propagation plane 220.

[0046] Also in Figure 4 is an instrument 460 shown inserted into the patient's 160 shoulder 155. The placement of the instrument 460 within the patient's 160 shoulder 155 can be adjusted using appropriate ultrasound transducer 110 positions and the resultant displayed ultrasound and model images 180,185. The instrument 460 can be configured for providing medical treatment to the patient 160 or for obtaining diagnostic information regarding the patient 160 such as obtaining a biopsy.

[0047] Figure 5 is a side view of a three-dimensional reconstructed model 560 from the anatomic model data 186 for the arrangement of Figure 4. In Figure 5 are shown a first, a second, a third, a fourth, and a fifth model features 510a,510b,510c,510d,510e that in order correspond to the first, the second, the third, the fourth, and the fifth specimen features 210a,210b,210c,210d,210e and a first, a second, and a third model reference points 515a,515b,515c that in order correspond to the first, the second, and the third specimen reference points 215a,215b,215c shown in Figure 4. Also shown in Figure 5 is a model image plane 520 that corresponds to the propagation plane 220 (the ultrasound image plane 220) of Figure 4. Note that the first, the second, and the third model features 510a,510b,510c and their associated first, second, and third model reference points 515a,515b,515c lie in another model image plane 520a referred to herein as the reference model image plane 520a. The reference model image plane 520a for the model image 185 that includes the first, second, and third model reference points 515a,515b,515c corresponds to the reference ultrasound image plane 220a for the ultrasound image 180 that includes the first, second, and third specimen reference points 215a,215b,215c. Note also, that Figure 5 does not include a model feature 510 that corresponds to the patient unique feature 450 as such items are not a part of the anatomic model data 186.

[0048] Figure 6 is another drawing of the display module 135 of Figures 1A, 1B, and 1C with the ultrasound transducer 110 placed as in Figure 4. In Figure 6, as in Figures 1A, 1B, and 1C, the ultrasound image 180 is displayed on the ultrasound display 140 and a corresponding model image 185 is preferably displayed concurrently on the model display 145. The model image 185 is a display of a two-dimensional slice through a representative model of the patient 160 for a plane that corresponds to the propagation plane 220 of the ultrasound incident wave 201 shown in Figure 4. The ultrasound reflection of the fourth and the fifth specimen features 210d,210e and the patient unique feature 450 of the ultrasound image 180 of the patient's shoulder 155 are indicated on the ultrasound display 140, and the corresponding model features 510 (fourth model feature 510d and fifth model feature 510ec) are shown on the model image 185 displayed on the model display 145.

[0049] Other locations of the ultrasound transducer 110 will result in displayed ultrasound and model images 180,185 for other propagation planes 220. A set of ultrasound data 187 for the ultrasound image 180 can be stored for future reference and future creation of ultrasound images 180 in the ultrasound memory 127 of the memory module 125. The stored set of ultrasound data 187 can be keyed to or stored with a set of model extracted data 188 obtained from the anatomic model data 186 for the region of that part 155 of the patient 160 from which the ultrasound data 187 was obtained.

[0050] The two specimen features 210d,210e, the patient unique feature 450, and the two model features 510d,510e in Figure 6 are shown for illustrative purposes only and are not intended to represent any particular feature 210 or patient unique feature 450 in the shoulder 155 or any other part 155 of the patient 160.

[0051] Figure 7 is a drawing of an alternative embodiment of a display module 135 for the apparatuses 100 of Figures 1A, 1B, and 1C. The display module 135 of Figure 7 comprises a single display 710 in a split screen mode for the combined display of the ultrasound image 180 and the model image 185. For ease and clarity of illustration, the two specimen features 210d,210e and the patient unique feature 450 as well as the corresponding two model features 510d,510e are not labeled in Figure 7 as they were in Figure 6.

[0052] As in Figure 6, other locations of the ultrasound transducer 110 will result in displayed ultrasound and model images 180,185 for other propagation planes 220. A set of ultrasound data 187 for the ultrasound image 180 can be stored for future reference and future creation of ultrasound images 180 in the ultrasound memory 127 of the memory module 125. The stored set of ultrasound data 187 can be keyed to or stored with a set of model extracted data 188 obtained from the anatomic model data 186 for the region of that part 155 of the patient 160 from which the ultrasound data 187 was obtained.

[0053] Figure 8 is a flow chart of a method 800 for the identification of organic specimen 160 features 210 in ultrasound images 180 as described in various representative embodiments. In block 805 of Figure 8, three model reference points 515 (first, second, and third model reference points 515a,515b,515c) are selected. Block 805 then transfers control to block 810.

[0054] In block 810, the ultrasound transducer 110 is coupled to the organic specimen 160 which could be, for example, the patient 160. Block 810 then transfers control to block 815.

[0055] In block 815, the ultrasound transducer 110 is moved until the three specimen reference points 215 (first, second, and third specimen reference points 215a,215b,215c) on the patient 160 that correspond to the three model reference points 515 (first, second, and third model reference points 515a,515b,515c) are located and marked on the ultrasound data 187. Block 815 then transfers control to block 820.

[0056] In block 820, the reference propagation plane 220a is identified based on the first, the second, and the third specimen reference points 215a,215b,215c. Block 820 then transfers control to block 825.

[0057] In block 825, the ultrasound transducer 110 is moved to a new location on the patient 160. Block 825 then transfers control to block 830.

[0058] In block 830, data specifying the new location of the ultrasound transducer 110 is transferred by the location detection unit 190 to the processor 130, and the reflected data signal 173 is transferred to the processor 130 from which a set of ultrasound data 187 is obtained. Block 830 then transfers control to block 835.

[0059] In block 835, the set of ultrasound data 187 is stored in the ultrasound memory 127. Block 835 then transfers control to block 837.

[0060] In block 837, a set of model extracted data 188 is obtained from the anatomic model data 186 in the anatomic model memory 126 for the region from which the set of ultrasound data 187 is obtained. Block 837 then transfers control to block 840.

[0061] In block 840, the corresponding set of model extracted data 188 is stored in the extracted model memory 128. Block 840 then transfers control to block 845.

[0062] In block 845, an ultrasound image 180 is created from the set of ultrasound data 187, and a corresponding model image 185 is created from the associated set of model extracted data 188. Block 845 then transfers control to block 850.

[0063] In block 850, the ultrasound image 180 and the corresponding model image 185 are displayed on the display module 135. Block 850 then transfers control to block 855.

[0064] In block 855, if an additional ultrasound image 180 and corresponding model image 185 are to be obtained, block 855 transfers control back to block 825.

Otherwise, block 855 terminates the process.

[0065] Figure 9 is a flow chart of another method 900 for the identification of organic specimen 160 features 210 in ultrasound images 180 as described in various representative embodiments. In block 905 of Figure 9, a reference model image plane 520a in anatomic model data 186 of at least a part 155 of an organic specimen 160 is identified. Block 905 then transfers control to block 910.

[0066] In block 910, a corresponding reference ultrasound image plane 220a is identified by transmitting one or more ultrasound incident waves 201 into the organic specimen 160 and receiving corresponding one or more ultrasound reflected waves 202. Positional awareness is maintained between the one or more ultrasound reflected waves 202. Block 910 then transfers control to block 915.

[0067] In block 915, at least one subsequent ultrasound incident wave 201 is transmitted into the organic specimen 160 and at least one corresponding subsequent ultrasound reflected wave 202 reflected from one or more specimen features 210 in the organic specimen 160 is received. Positional awareness is maintained between the reference ultrasound plane 220a and a propagation plane 220 of the at least one subsequent ultrasound incident wave 201. Block 915 then transfers control to block 920.

[0068] In block 920, for at least one subsequent ultrasound reflected wave 202, an ultrasound image 180, is created therefrom. Block 920 then transfers control to block 925.

[0069] In block 925, for the at least one subsequent ultrasound reflected wave 202, a corresponding model image 185 from the anatomic model data 186 for the model image plane 520 that corresponds to the ultrasound image plane 220 for the at least one subsequent ultrasound reflected wave 202 is created. Block 925 then transfers control to block 930.

[0070] In block 930, for the at least one subsequent ultrasound reflected wave 202, the ultrasound image 180 and the model image 185 are displayed on a display module 135. Block 930 then transfers control to block 935.

[0071] In block 935, for the at least one subsequent ultrasound reflected wave 202, a specimen feature 210 on the ultrasound image 180 is identified from a corresponding model feature 510 on the model image 185. Block 935 then terminates the process.

[0072] While the representative embodiments disclosed herein have been discussed in terms of the ultrasound transducer 110 coupled to the shoulder 155 of a human patient 160, it will be understood by one of ordinary skill in the art that other representative embodiments can be implemented for use with other parts 155 of any organic specimen 160. As stated above, an organic specimen 160 is any living or deceased organism or any portion of a living or deceased organism. In particular, the organic specimen could be a human, another animal, a plant, or a portion of a human, another animal, or a plant.

[0073] In representative embodiments, the ultrasound images 180 and/or the model images 185 could be stored in the memory module 125.

[0074] In alternative representative embodiments, the ultrasound controller 120 could be implemented in hardware, as a software program, or in firmware either external to or internal to the processor 130. In alternative representative embodiments, the location identification module 195 could be implemented in hardware, as a software program, or in firmware either external to or internal to the processor 130.

[0075] In other representative embodiments, the propagation plane 220 could be adjusted electronically rather than by a physical movement of the ultrasound transducer 110 relative to the organic specimen 160.

[0076] The term region as used herein refers to a plane or slice for two-dimensional embodiments and to a volume for three-dimensional embodiments. Generally for both two-dimensional and three-dimensional embodiments, the propagation plane 220 is referred to as the propagation region 220, the ultrasound image plane 220 is referred to as the ultrasound image region 220, the reference propagation plane 220a is referred to as the reference propagation region 220a, and the reference ultrasound image plane 220a is referred to as the reference ultrasound image region 220a. Also generally for both two-dimensional and three-dimensional embodiments, the model image plane 520 and the reference model image plane 520a are referred to respectively as the model image region 520 and the reference model region 520a.

[0077] The anatomic model data 186 could be obtained from data sets such as or similar to the Visible Human Project® (VHP) which can be used to create model images 185 of a representative human body (male or female) at diverse selected depths and angular orientations. The anatomic model data 186 could also be based on a theoretical model of an organic specimen 160. The anatomic model data 186 stored in the memory module 125 can be anatomic model data 186 of at least part 155 of the organic specimen 160. The processor 130 could be a central processing unit (CPU) 130 and could be located in a computer. The memory module 125 could be a computer memory 125.

[0078] In addition, while representative embodiments herein have been discussed in terms of creating and displaying static, two-dimensional ultrasound images 180, the ultrasound images 180 could also be static, three-dimensional ultrasound images 180, time varying, two-dimensional ultrasound images 180, and time varying, three-dimensional ultrasound images 180. Further, while representative embodiments herein have been discussed in terms of creating and displaying corresponding static, two-dimensional model images 185, the corresponding model images 185 could also be static, three-dimensional model images 185, time varying, two-dimensional model images 185, and time varying, three-dimensional model images 185.

[0079] Also, while representative embodiments disclosed herein have been discussed in terms of the various modules, components, and functions being located on or operatively coupled to a single processor 130, multiple processors 130 can instead be employed. And further, while representative embodiments disclosed herein have been discussed in terms of the various modules, components, and functions being located locally, at least one of these can instead be distributed.

[0080] In a first representative embodiment, an apparatus 100 is disclosed. The apparatus 100 comprises an ultrasound transducer 110 configured for transmitting ultrasound incident waves 201 into selected regions 220 of an organic specimen 160, detecting resultant ultrasound reflected waves 202 from specimen features 210 of the organic specimen 160, and transferring ultrasound data 187 in the resultant ultrasound reflected waves 202 for each of multiple selected ultrasound incident waves 201 to a processor 130; a location detection unit 190 configured for detecting locations of the ultrasound transducer 110 and the organic specimen 160 and for transferring that location data 194 to the processor 130; a memory module 125 configured for storing anatomic model data 186 for at least part 155 of the organic specimen 160; the processor 130 configured for identifying the region 220 associated with selected ultrasound data 187 using location data 194 and one or more sets of ultrasound data 187 resultant from reflections of recognized specimen features 210, creating an ultrasound image 180 from the selected ultrasound data 187, obtaining model extracted data 188 from the anatomic model data 186 corresponding to that of the selected ultrasound data 187 region 220, creating a model image 185 from that model extracted data 188, and transferring the ultrasound image 180 and the model image 185 to a display module 135; and the display module 135 configured for displaying the ultrasound image 180 and the model image 185.

[0081] In an optional aspect of the first representative embodiment, wherein the memory module 125 is further configured for storing the model extracted data 188.

[0082] In an optional aspect of the first representative embodiment, wherein the memory module 125 is further configured for storing the ultrasound data 187.

[0083] In an optional aspect of the first representative embodiment, wherein the processor 130 is configured for creating and the display module 135 is configured for displaying at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0084] In an optional aspect of the first representative embodiment, wherein the processor 130 is a central processing unit 130.

[0085] In an optional aspect of the first representative embodiment, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0086] In an optional aspect of the first representative embodiment, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0087] In an optional aspect of the first representative embodiment, wherein the model image 185 and the ultrasound image 180 are scaled to each other.

[0088] In an optional aspect of the first representative embodiment, wherein the anatomic model data 186 is obtained from the Visible Human Project data 186 for a representative human male or a representative human female.

[0089] In an optional aspect of the first representative embodiment, wherein the anatomic model data 186 is of a representative human male or a representative human female.

[0090] In an optional aspect of the first representative embodiment, wherein the resultant ultrasound reflected wave 202 further comprises reflections from a patient unique feature 450 in the organic specimen 160.

[0091] In an optional aspect of the first representative embodiment, wherein the resultant ultrasound reflected wave 202 further comprises reflections from an instrument 460 inserted into the organic specimen 160 when the ultrasound transducer 110 is appropriately located.

[0092] In an optional aspect of the first representative embodiment, wherein the resultant ultrasound reflected wave 202 further comprises reflections from an instrument 460 inserted into the organic specimen 160 when the ultrasound transducer 110 is appropriately located and wherein the instrument 460 is configured for providing medical treatment to the organic specimen 160 or is configured for providing diagnostic information regarding the organic specimen 160.

[0093] In a second representative embodiment, a method is disclosed. The method comprises specifying a reference model image region 520a in model extracted data 188 obtained from anatomic model data 186 of at least part 155 of an organic specimen 160; transmitting ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness 194 of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; identifying a reference propagation region 220a corresponding to the reference model image region 520a from paired recognized specimen features 210 in the ultrasound data

202 and in the model extracted data 188; transmitting at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and the propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180, creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187, and displaying the ultrasound image 180 and the model image 185 on a display module 135.

[0094] In an optional aspect of the second representative embodiment, the method 900 further comprises identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0095] In an optional aspect of the second representative embodiment, wherein the reference model image region 520a is a plane 520a and is specified by three non-collinear model reference points 515a,515b,515c in the anatomic model data 186 of at least part 155 of the organic specimen 160.

[0096] In an optional aspect of the second representative embodiment, wherein the reference model image region 520a is a plane 520a and is specified by three non-collinear model reference points 515a,515b,515c in the anatomic model data 186 of at least part 155 of the organic specimen 160 and wherein the reference propagation region 220a in the organic specimen 160 is a plane 220a corresponding to the reference model image plane 520a and is identified when one or more ultrasound incident waves 201 are reflected separately or in combination from three specimen reference points 215a,215b,215c corresponding to the three model reference points 515a,515b,515c.

[0097] In an optional aspect of the second representative embodiment, wherein the model extracted data 188 is stored in a memory module 125.

[0098] In an optional aspect of the second representative embodiment, wherein the ultrasound data 187 is stored in a memory module 125.

[0099] In an optional aspect of the second representative embodiment, wherein displaying the ultrasound image 180 and the model image 185 on the display module 135 comprises: displaying at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or displaying at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or displaying at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or displaying at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0100] In an optional aspect of the second representative embodiment, wherein the anatomic model data 186 is stored in a memory module 125.

[0101] In an optional aspect of the second representative embodiment, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0102] In an optional aspect of the second representative embodiment, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0103] In an optional aspect of the second representative embodiment, wherein the model image 185 and the ultrasound image 180 are scaled to each other.

[0104] In an optional aspect of the second representative embodiment, wherein the anatomic model data 186 is obtained from the Visible Human Project data 186 for a representative human male or a representative human female.

[0105] In an optional aspect of the second representative embodiment, wherein the anatomic model data 186 is for a representative human male or a representative human female.

[0106] In an optional aspect of the second representative embodiment, further comprising: detecting a patient unique feature 450 in the organic specimen 160.

[0107] In an optional aspect of the second representative embodiment, further comprising: inserting an instrument 460 into the organic specimen 160; and adjusting the instrument 460 position within the organic specimen 160 using the displayed ultrasound image 180 and displayed model image 185.

[0108] In an optional aspect of the second representative embodiment, further comprising: inserting an instrument 460 into the organic specimen 160; and adjusting the instrument 460 position within the organic specimen 160 using the displayed ultrasound image 180 and displayed model image 185, wherein the instrument 460 is configured for providing medical treatment to the organic specimen 160 or is configured for providing diagnostic information regarding the organic specimen 160.

[0109] In a third representative embodiment, a means 100 for identification of an organic specimen 160 feature 210 in an ultrasound image 180 is disclosed. The means comprises an ultrasound means 110 for transmitting ultrasound incident waves 201 into selected regions 210 of an organic specimen 160, detecting resultant ultrasound reflected waves 202 from specimen features 210 of the organic specimen 160, and transferring ultrasound data 187 in the resultant ultrasound reflected waves 202 for each of multiple selected ultrasound incident waves 201 to a processor means 130; a location detection means 190 for detecting locations of the ultrasound means 110 and the organic specimen 160 and for transferring that location data 194 to the processor means 130; a memory means 125 for storing anatomic model data 186 for at least part 155 of the organic specimen 160; the processor means 130 for identifying a region 220 of the organic specimen 160 associated with selected ultrasound data 187 using location data 194 and one or more sets of ultrasound data 187 resultant from reflections of recognized specimen features 210, creating an ultrasound image 180 from the selected ultrasound data 187, obtaining model extracted data 188 from the anatomic model data 186 corresponding to that of the selected ultrasound data 187 region 220, creating a model image 185 from the model extracted data 188, and transferring the ultrasound image 180 and the model image 185 to a display means 135; and the display means 135 configured for displaying the ultrasound image 180 and the model image 185.

[0110] In a fourth representative embodiment, a computer program product 133 stored on a non-transitory computer readable storage medium for carrying out a method 900 when executed on a computer 132 is disclosed. The method 900 comprises specifying a reference model image region 520a in model extracted data 188 obtained from anatomic model data 186 of at least part 155 of an organic specimen 160; instructing an ultrasound transducer 110 to transmit ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness 194 of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; identifying a reference propagation region 220a corresponding to the reference model image region 520a from paired recognized specimen features 210 in the ultrasound data 202 and in the model extracted data 188; instructing an ultrasound transducer 110 to transmit at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and the propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180, creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187, and instructing a display module 135 to display the ultrasound image 180 and the model image 185.

[0111] In an optional aspect of the fourth representative embodiment, the method 900 further comprising: identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0112] In an optional aspect of the fourth representative embodiment, wherein the reference model image region 520a is a plane 520a and is specified by three non-collinear model reference points 515a,515b,515c in the anatomic model data 186 of at least part 155 of the organic specimen 160.

[0113] In an optional aspect of the fourth representative embodiment, wherein the reference model image region 520a is a plane 520a and is specified by three non-collinear model reference points 515a,515b,515c in the anatomic model data 186 of at least part 155 of the organic specimen 160 and wherein the reference propagation region 220a in the organic specimen 160 is a plane 220a corresponding to the reference model image plane 520a and is identified when one or more ultrasound incident waves 201 are reflected separately or in combination from three specimen reference points 215a,215b,215c corresponding to the three model reference points 515a,515b,515c.

[0114] In an optional aspect of the fourth representative embodiment, wherein the model extracted data 188 is stored in a memory module 125.

[0115] In an optional aspect of the fourth representative embodiment, wherein the ultrasound data 187 is stored in a memory module 125.

[0116] In an optional aspect of the fourth representative embodiment, wherein instructing the display module 135 to display the ultrasound image 180 and the model image 185 comprises: an instruction to display at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or an instruction to display at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or an instruction to display at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or an instruction to display at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0117] In an optional aspect of the fourth representative embodiment, wherein the anatomic model data 186 is stored in a memory module 125.

[0118] In an optional aspect of the fourth representative embodiment, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0119] In an optional aspect of the fourth representative embodiment, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0120] In an optional aspect of the fourth representative embodiment, wherein the model image 185 and the ultrasound image 180 are scaled to each other.

[0121] In an optional aspect of the fourth representative embodiment, wherein the anatomic model data 186 is obtained from the Visible Human Project data 186 for a representative human male or a representative human female.

[0122] In an optional aspect of the fourth representative embodiment, wherein the anatomic model data 186 is for a representative human male or a representative human female.

[0123] In an optional aspect of the fourth representative embodiment, the method 900 further comprising: detecting a patient unique feature 450 in the organic specimen 160.

[0124] In a fifth representative embodiment, a non-transitory computer-readable medium 125 having computer-executable instructions for causing a computer 132 comprising a processor 130 and associated memory 125 to carry out a method 900 is disclosed. The method 900 comprises specifying a reference model image region 520a in model extracted data 188 obtained from anatomic model data 186 of at least part 155 of an organic specimen 160; instructing an ultrasound transducer 110 to transmit ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness 194 of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; identifying a reference propagation region 220a corresponding to the reference model image region 520a from paired recognized specimen features 210 in the ultrasound data 202 and in the model extracted data 188; instructing an ultrasound transducer 110 to transmit at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and the propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180, creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187, and instructing a display module 135 to display the ultrasound image 180 and the model image 185.

[0125] Embodiment 1 is directed to a method 900, the method 900 comprises obtaining anatomic model data 186 corresponding to at least part 155 of an organic specimen 160; specifying a reference model image region 520a in the anatomic model data 186; transmitting ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; and identifying a reference propagation region 220a corresponding to the reference model image region 520a using paired equivalent specimen features 210 in the ultrasound data 187 and in the anatomic model data 186.

[0126] Embodiment 2 is directed to embodiment 1, wherein the anatomic model data 186 is obtained from at least part of data 186 for a representative human male or a representative human female.

[0127] Embodiment 3 is directed to embodiment 1, wherein the anatomic model data 186 is for at least part 155 of a representative organic specimen 160 that is other than the organic specimen 160 from which the ultrasound data 187 is obtained.

[0128] Embodiment 4 is directed to embodiment 1, further comprising transmitting at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and a propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180 and creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187.

[0129] Embodiment 5 is directed to embodiment 4, further comprising identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0130] Embodiment 6 is directed to embodiment 4, further comprising displaying the ultrasound image 180 and the model image 185 on a display module 135.

[0131] Embodiment 7 is directed to embodiment 6, wherein displaying the ultrasound image 180 and the model image 185 on the display module 135 comprises displaying at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or displaying at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or displaying at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or displaying at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0132] Embodiment 8 is directed to embodiment 6, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0133] Embodiment 9 is directed to embodiment 6, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0134] Embodiment 10 is directed to embodiment 6, further comprising detecting an aberrant feature 450 in the organic specimen 160.

[0135] Embodiment 11 is directed to a non-transitory computer-readable medium 125 having computer-executable instructions for causing a computer 132 comprising a processor 130 and associated memory 125 to carry out a method 900, the method 900 comprising obtaining anatomic model data 186 corresponding to at least part 155 of an organic specimen 160; specifying a reference model image region 520a in the anatomic model data 186; instructing an ultrasound transducer 110 to transmit ultrasound incident waves 201 into the organic specimen 160 and receiving thereby ultrasound data 187 from ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; and identifying a reference propagation region 220a corresponding to the reference model image region 520a using paired equivalent specimen features 210 in the ultrasound data 187 and in the anatomic model data 186.

[0136] Embodiment 12 is directed to embodiment 11, wherein the anatomic model data 186 is obtained from at least part of data 186 for a representative human male or a representative human female.

[0137] Embodiment 13 is directed to embodiment 11, wherein the anatomic model data 186 is for at least part 155 of a representative organic specimen 160 that is other than the organic specimen 160 from which the ultrasound data 187 is obtained.

[0138] Embodiment 14 is directed to embodiment 11, the method 900 further comprising instructing the ultrasound transducer 110 to transmit at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and a propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180 and creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187.

[0139] Embodiment 15 is directed to embodiment 14, the method 900 further comprising identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0140] Embodiment 16 is directed to embodiment 14, the method 900 further comprising instructing a display module 135 to display the ultrasound image 180 and the model image 185.

[0141] Embodiment 17 is directed to embodiment 16, wherein instructing the display module 135 to display the ultrasound image 180 and the model image 185 comprises an instruction to display at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or an instruction to display at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or an instruction to display at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or an instruction to display at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0142] Embodiment 18 is directed to embodiment 16, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0143] Embodiment 19 is directed to embodiment 16, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0144] Embodiment 20 is directed to embodiment 16, the method 900 further comprising detecting an aberrant feature 450 in the organic specimen 160.

[0145] Embodiment 21 is directed to a method 900, the method 900 comprising transmitting ultrasound incident waves 201 into an organic specimen 160 and receiving thereby ultrasound data 187 from resultant ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; obtaining anatomic model data 186 corresponding to at least part 155 of the organic specimen 160; and identifying a reference model image region 520a in the anatomic model data 186 and a corresponding reference propagation region 220a in the organic specimen 160 using paired equivalent specimen features 210 in the anatomic model data 186 and in the ultrasound data 187.

[0146] Embodiment 22 is directed to embodiment 21, wherein the anatomic model data 186 is obtained from at least part of data 186 for a representative human male or a representative human female.

[0147] Embodiment 23 is directed to embodiment 21, wherein the anatomic model data 186 is for at least part 155 of a representative organic specimen 160 that is other than the organic specimen 160 from which the ultrasound data 187 is obtained.

[0148] Embodiment 24 is directed to embodiment 21, the method 900 further comprising transmitting at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and a propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180 and creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187.

[0149] Embodiment 25 is directed to embodiment 24, the method 900 further comprising identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0150] Embodiment 26 is directed to embodiment 24, the method 900 further comprising displaying the ultrasound image 180 and the model image 185 on a display module 135.

[0151] Embodiment 27 is directed to embodiment 26, wherein displaying the ultrasound image 180 and the model image 185 on the display module 135 comprises displaying at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or displaying at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or displaying at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or displaying at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0152] Embodiment 28 is directed to embodiment 26, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0153] Embodiment 29 is directed to embodiment 26, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0154] Embodiment 30 is directed to embodiment 26, the method 900 further comprising detecting an aberrant feature 450 in the organic specimen 160.

[0155] Embodiment 31 is directed to a non-transitory computer-readable medium 125 having computer-executable instructions for causing a computer 132 comprising a processor 130 and associated memory 125 to carry out a method 900, the method 900 comprising transmitting ultrasound incident waves 201 into an organic specimen 160 and receiving thereby ultrasound data 187 from resultant ultrasound reflected waves 202 from specimen features 210 in the organic specimen 160, wherein positional awareness of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; obtaining anatomic model data 186 corresponding to at least part 155 of the organic specimen 160; and identifying a reference model image region 520a in the anatomic model data 186 and a corresponding reference propagation region 220a in the organic specimen 160 using paired equivalent specimen features 210 in the anatomic model data 186 and in the ultrasound data 187.

[0156] Embodiment 32 is directed to embodiment 31, wherein the anatomic model data 186 is obtained from at least part of data 186 for a representative human male or a representative human female.

[0157] Embodiment 33 is directed to embodiment 31, wherein the anatomic model data 186 is for at least part 155 of a representative organic specimen 160 that is other than the organic specimen 160 from which the ultrasound data 187 is obtained.

[0158] Embodiment 34 is directed to embodiment 31 , the method 900 further comprising instructing an ultrasound transducer 110 to transmit at least one subsequent ultrasound incident wave 201 into the organic specimen 160 and receiving thereby subsequent ultrasound data 187 from ultrasound reflected waves 202 from one or more specimen features 210, wherein positional awareness is maintained between the reference propagation region 220a and a propagation region 220 of the subsequent ultrasound data 187; and for the subsequent ultrasound data 187, creating an ultrasound image 180 and creating a model image 185 for a model image region 520 from the anatomic model data 186 corresponding to the propagation region 220 of the subsequent ultrasound data 187.

[0159] Embodiment 35 is directed to embodiment 34, the method 900 further comprising identifying at least one specimen feature 210 on the ultrasound image 180 from a corresponding model feature 510 on the model image 185.

[0160] Embodiment 36 is directed to embodiment 34, the method 900 further comprising instructing a display module 135 to display the ultrasound image 180 and the model image 185.

[0161] Embodiment 37 is directed to embodiment 36, wherein instructing the display module 135 to display the ultrasound image 180 and the model image 185 comprises an instruction to display at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or an instruction to display at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or an instruction to display at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or an instruction to display at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0162] Embodiment 38 is directed to embodiment 36, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0163] Embodiment 39 is directed to embodiment 36, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0164] Embodiment 40 is directed to embodiment 36, the method 900 further comprising detecting an aberrant feature 450 in the organic specimen 160.

[0165] Embodiment 41 is directed to an apparatus 100, the apparatus 100 comprising a processor 130 configured for receiving ultrasound data 187 from ultrasound reflected waves 202, wherein the ultrasound reflected waves 202 result from reflections of ultrasound incident waves 201 by specimen features 210 in an organic specimen 160 and wherein positional awareness of each ultrasound reflected wave 202 relative to the organic specimen 160 is maintained; obtaining anatomic model data 186 corresponding to at least part 155 of the organic specimen 160; and identifying a reference model image region 520a in the anatomic model data 186 and a corresponding reference propagation region 220a in the organic specimen 160 using paired equivalent specimen features 210 in the anatomic model data 186 and in the ultrasound data 187.

[0166] Embodiment 42 is directed to embodiment 41, wherein the anatomic model data 186 is obtained from at least part of data 186 for a representative human male or a representative human female.

[0167] Embodiment 43 is directed to embodiment 41, wherein the anatomic model data 186 is for at least part 155 of a representative organic specimen 160 that is other than the organic specimen 160 from which the ultrasound data 187 is obtained.

[0168] Embodiment 44 is directed to embodiment 41, further comprising a location detection unit 190 configured for detecting locations of an ultrasound transducer 110 and the organic specimen 160 and for transferring that location data 194 to the processor 130.

[0169] Embodiment 45 is directed to embodiment 41, further comprising a memory module 125 configured for storing anatomic model data 186 for at least part 155 of the organic specimen 160 and/or the ultrasound data 187.

[0170] Embodiment 46 is directed to embodiment 41, further comprising a display module 135, wherein the processor 130 is further configured for identifying the region 220 associated with selected ultrasound data 187 using location data 194 and one or more sets of ultrasound data 187 resultant from reflections of equivalent specimen features 210, creating an ultrasound image 180 from the selected ultrasound data 187, obtaining model extracted data 188 from the anatomic model data 186 corresponding to that of the selected ultrasound data 187 region 220, creating a model image 185 from that model extracted data 188, and transferring the ultrasound image 180 and the model image 185 to the display module 135, wherein the display module 135 is configured for displaying the ultrasound image 180 and the model image 185.

[0171] Embodiment 47 is directed to embodiment 46, wherein the processor 130 is configured for creating and the display module 135 is configured for displaying at least one static, two-dimensional ultrasound image 180 and its associated static, two-dimensional model image 185, and/or at least one static, three-dimensional ultrasound image 180 and its associated static, three-dimensional model image 185, and/or at least one set of time varying, two-dimensional ultrasound images 180 and its associated set of time varying, two-dimensional model images 185, and/or at least one set of time varying, three-dimensional ultrasound images 180 and its associated set of time varying, three-dimensional model images 185.

[0172] Embodiment 48 is directed to embodiment 46, wherein the display module 135 comprises a first display 140 and a second display 145 and wherein the ultrasound image 180 is displayed on the first display 140 and the model image 185 is displayed on the second display 145.

[0173] Embodiment 49 is directed to embodiment 46, wherein the ultrasound image 180 and the model image 185 are overlaid on the display module 135 or wherein the ultrasound image 180 and the model image 185 are displayed side-by-side on the display module 135.

[0174] Embodiment 50 is directed to embodiment 41, wherein the resultant ultrasound reflected wave 202 further comprises reflections from an aberrant feature 450 in the organic specimen 160.

[0175] In representative embodiments, the anatomic model data 186 for at least part of the organic specimen 160 can be for a representative organic specimen, a representative human male, and/or a representative human female that is other than the organic specimen 160 or patient 160 from which ultrasound data 187 is obtained.

[0176] In representative embodiments, various technical steps do not require the presence of a human subject 160 or any other organic specimen 160. These technical steps include, among others, obtaining anatomic model data 186 corresponding to at least part 155 of a human subject 160, specifying a reference model image region 520a in the anatomic model data 186, using equivalent specimen features 210 in the anatomic model data 186 to identify a reference propagation region 220a corresponding to the reference model image region 520a, creating a model image 185 for a model image region 520 from the anatomic model data 186, displaying the model image 185, creating an ultrasound image 180, and displaying the ultrasound image 180.

[0177] It will be appreciated that any module or component disclosed herein that executes instructions may include or otherwise have access to non- transient and tangible computer readable media such as storage media, computer storage media, or data storage devices (removable or non-removable) such as, for example, magnetic disks, optical disks, or tape data storage. Computer storage media may include volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data. Examples of computer storage media include RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by an application, module, or both. Any such computer storage media may be part of the server, any component of or related to the network, backend, etc., or accessible or connectable thereto. Any application or module herein described may be implemented using computer readable/executable instructions that may be stored or otherwise held by such computer readable media.

[0178] Certain embodiments described herein are or may be implemented using a programmed processor executing programming instructions that are broadly described above in flow chart form that can be stored on any suitable electronic or computer readable storage medium including non-transitory storage media. The term "non-transitory" is intended herein only to preclude propagating waves and not storage that can be rewritten or storage that loses its stored information when power is removed.

[0179] The representative embodiments, which have been described in detail herein, have been presented by way of example and not by way of limitation. It will be understood by those skilled in the art that various changes may be made in the form and details of the described embodiments resulting in equivalent embodiments that remain within the scope of the appended claims.

Claims

1. A method (900), comprising:

   receiving reference ultrasound data (187) from one or more ultrasound reflected waves (202) reflected from specimen features (210) in an organic specimen (160) resultant from one or more reference ultrasound incident waves (201) transmitted into the organic specimen (160) by an ultrasound transducer (110),
   wherein positional awareness of each of the one or more reference ultrasound incident waves (201) relative to the organic specimen (160) is maintained using locations of the ultrasound transducer (110) detected by a location detection unit (190);
   identifying a reference propagation region (220a) in the organic specimen (160) and a corresponding reference model region (520a) in anatomic model data (186) using the specimen feature (210) information in the reference ultrasound data (187) and associated positional awareness information paired with corresponding model feature (510) information in the anatomic model data (186),
   wherein the anatomic model data (186) correspond to at least part of the organic specimen (160); and
   receiving additional ultrasound data (187) from an additional ultrasound reflected wave (202) reflected from one or more specimen features (210) in the organic specimen (160) resultant from an additional ultrasound incident wave (201) transmitted into the organic specimen (160) in an additional propagation region (220) by the ultrasound transducer (110),
   wherein positional awareness is maintained between the reference propagation region (220a) and the additional propagation region (220) using locations of the ultrasound transducer (110) detected by the location detection unit (190).

2. The method (900) as recited in claim 1, wherein the reference propagation region (220a), the reference model region (520a), and the additional propagation region (220) are planes.

3. The method (900) as recited in claim 1, further comprising:
   identifying an additional model region (520) in the anatomic model data (186) corresponding to the additional propagation region (220) using positional awareness information.

4. The method (900) recited in claim 3, wherein the reference propagation region (220a), the reference model region (520a), the additional propagation region (220), and the additional model region (520) are planes.

5. The method (900) as recited in claim 3, further comprising:
   identifying at least one specimen feature (210) in the ultrasound data (187) of the additional propagation region (220) and its corresponding model feature (510) in the anatomic model data (186) of the additional model region (520).

6. The method (900) as recited in claim 3, further comprising:

   creating an ultrasound image (180) using the ultrasound data (187) for the additional propagation region (220) and/or
   creating a model image (185) using the anatomic model data (186) for the additional model region (520).

7. The method (900) as recited in claim 6, further comprising:
   identifying at least one specimen feature (210) in the ultrasound image (180) of the additional propagation region (220) and its corresponding model feature (510) in the model image (185) of the additional mod-

el region (520).

8. The method (900) as recited in claim 6, further comprising:
issuing a command to a display module (135) to display the ultrasound image (180) and/or the model image (185).

9. The method (900) as recited in claim 6, wherein the ultrasound image (180) and the model image (185) comprise:

a static, two-dimensional ultrasound image (180) and an associated static, two-dimensional model image (185), and/or
a static, three-dimensional ultrasound image (180) and an associated static, three-dimensional model image (185), and/or
a set of time varying, two-dimensional ultrasound images (180) and an associated set of time varying, two-dimensional model images (185), and/or
a set of time varying, three-dimensional ultrasound images (180) and an associated set of time varying, three-dimensional model images (185).

10. The method (900) as recited in claim 1, wherein the anatomic model data (186) comprise:

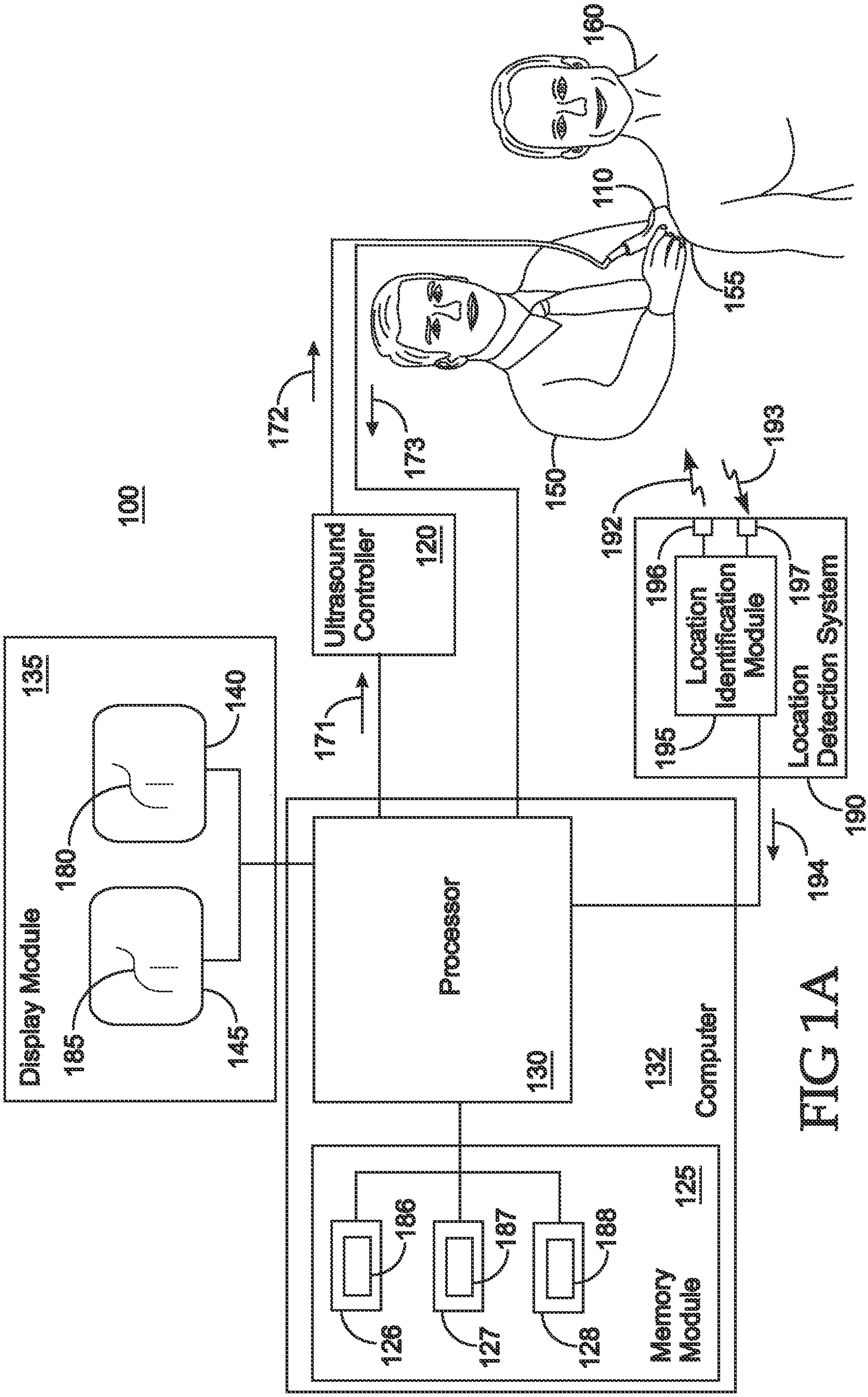
at least part of data from a representative human male or a representative human female, and/or
at least part of data from a representative organic specimen (160) that is other than the organic specimen (160) from which the ultrasound data (187) are obtained, and/or
at least part of data from the organic specimen (160) from which the ultrasound data (187) are obtained, and/or
information from one or more photographs and/or other images and/or other sets of data of one or more physical cross-sections of at least part of the organic specimen (160) or the representative organic specimen (160).

11. The method (900) as recited in claim 1, further comprising:
identifying a distinctive specimen feature (210) in, and/or an aberrant feature in, and/or an instrument (460) inserted into the organic specimen (160).

12. An apparatus (100) comprising an ultrasound transducer (110), a location detection unit (190) and means adapted to execute the steps of the method (900) according to any one of the claims 1 to 11.

13. A computer program (133) comprising instructions to cause the apparatus (100) of claim 12 to execute the steps of the method (900) according to any one of the claims 1 to 11.

14. A computer-readable medium (125) having stored thereon the computer program (133) of claim 13.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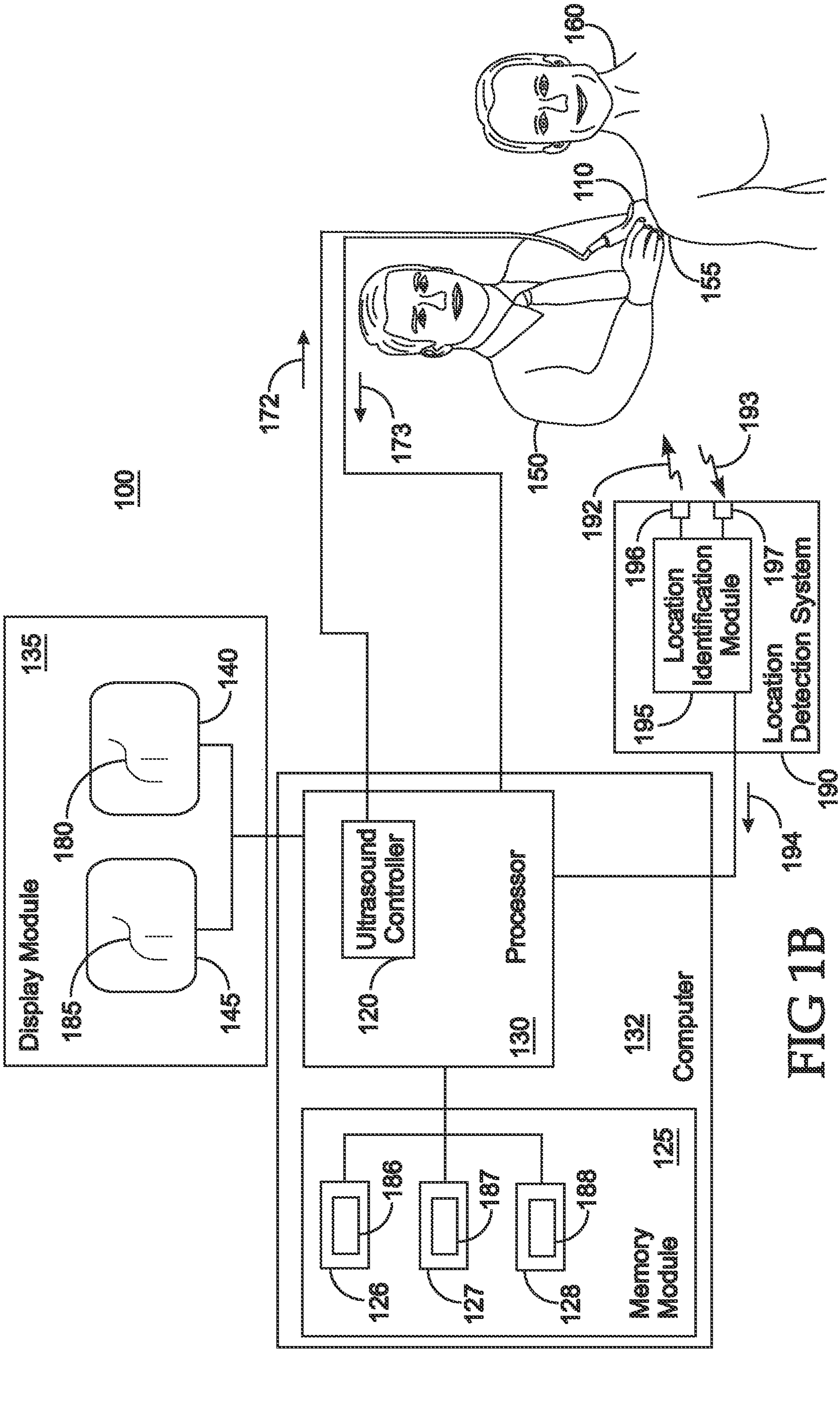
Display Module
135
185
145
180
140
Ultrasound Controller
120
171
172
173
150
155
110
160
Processor
130
132
Computer
Memory Module
125
126
127
128
186
187
188
Location Identification Module
195
196
197
Location Detection System
190
192
193
194

FIG 1A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135
140
180
185
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120
Processor
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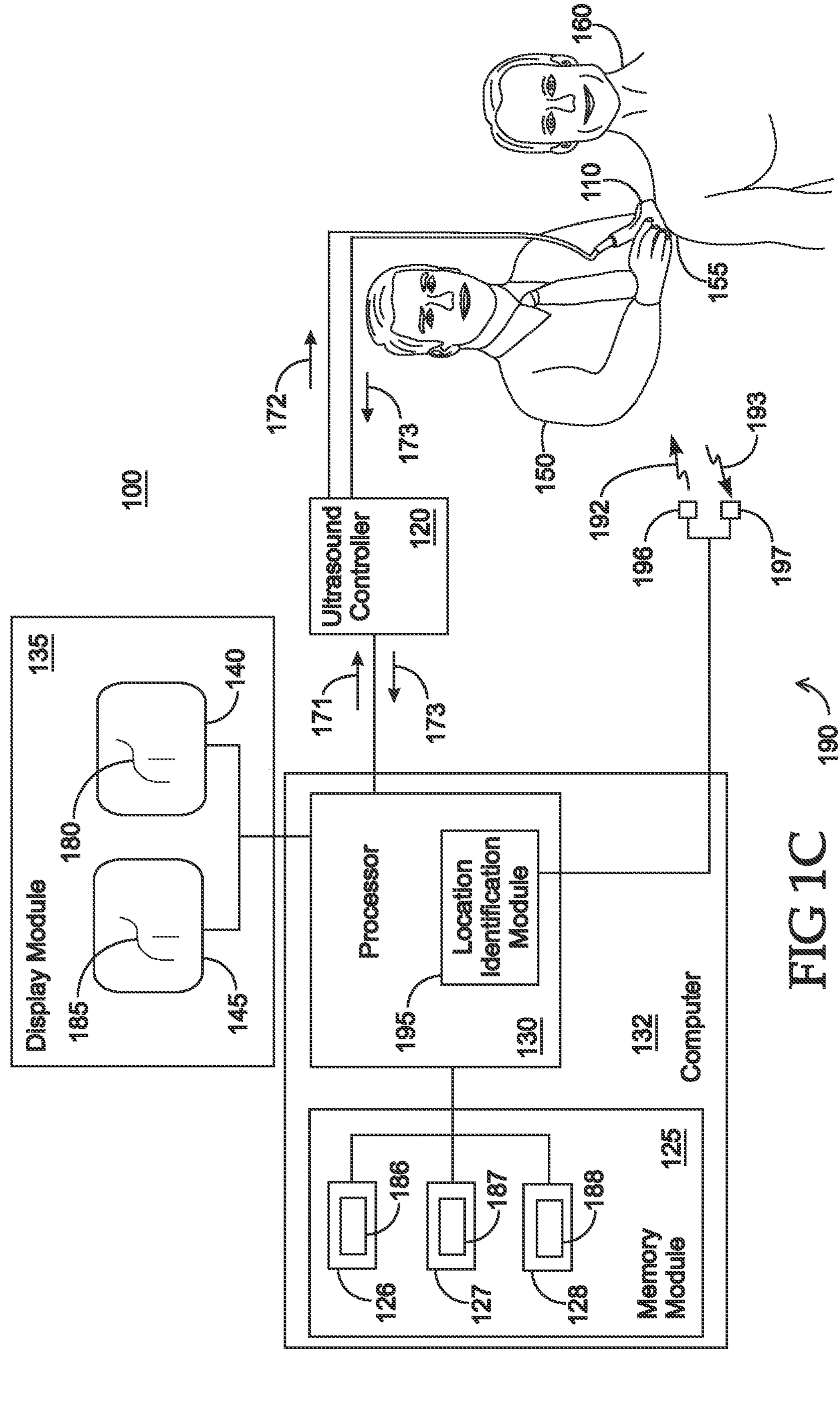
132
Computer
Memory Module
125
126
127
128
186
187
188
172
173
150
110
155
160
Location Identification Module
Location Detection System
190
192
193
194
195
196
197

FIG 1B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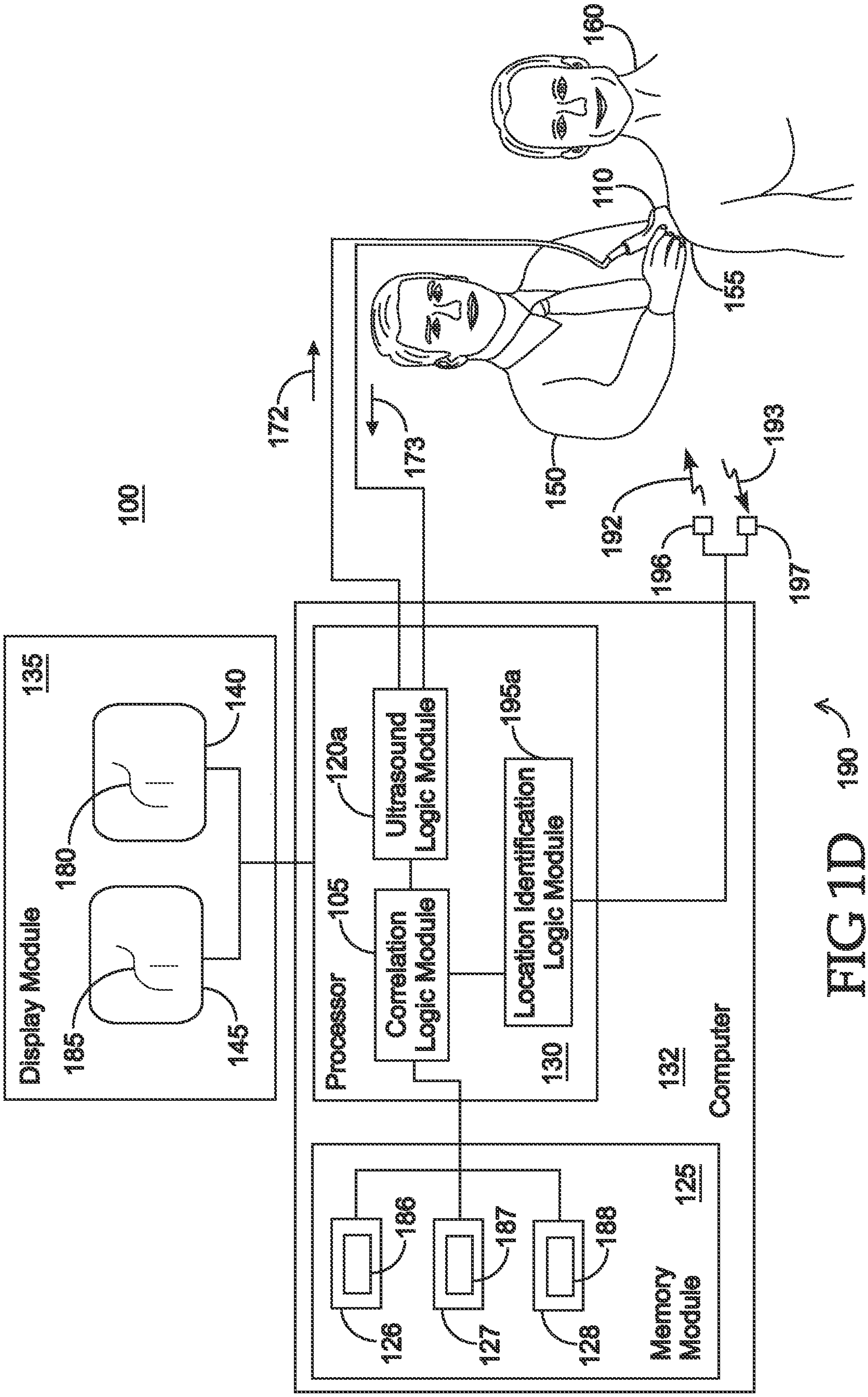
Display Module
135
185
145
180
140
Ultrasound Controller
120
171
173
172
173
150
110
155
160
Processor
Location Identification Module
195
130
132
Computer
Memory Module
125
126
127
128
186
187
188
192
193
196
197
190

FIG 1C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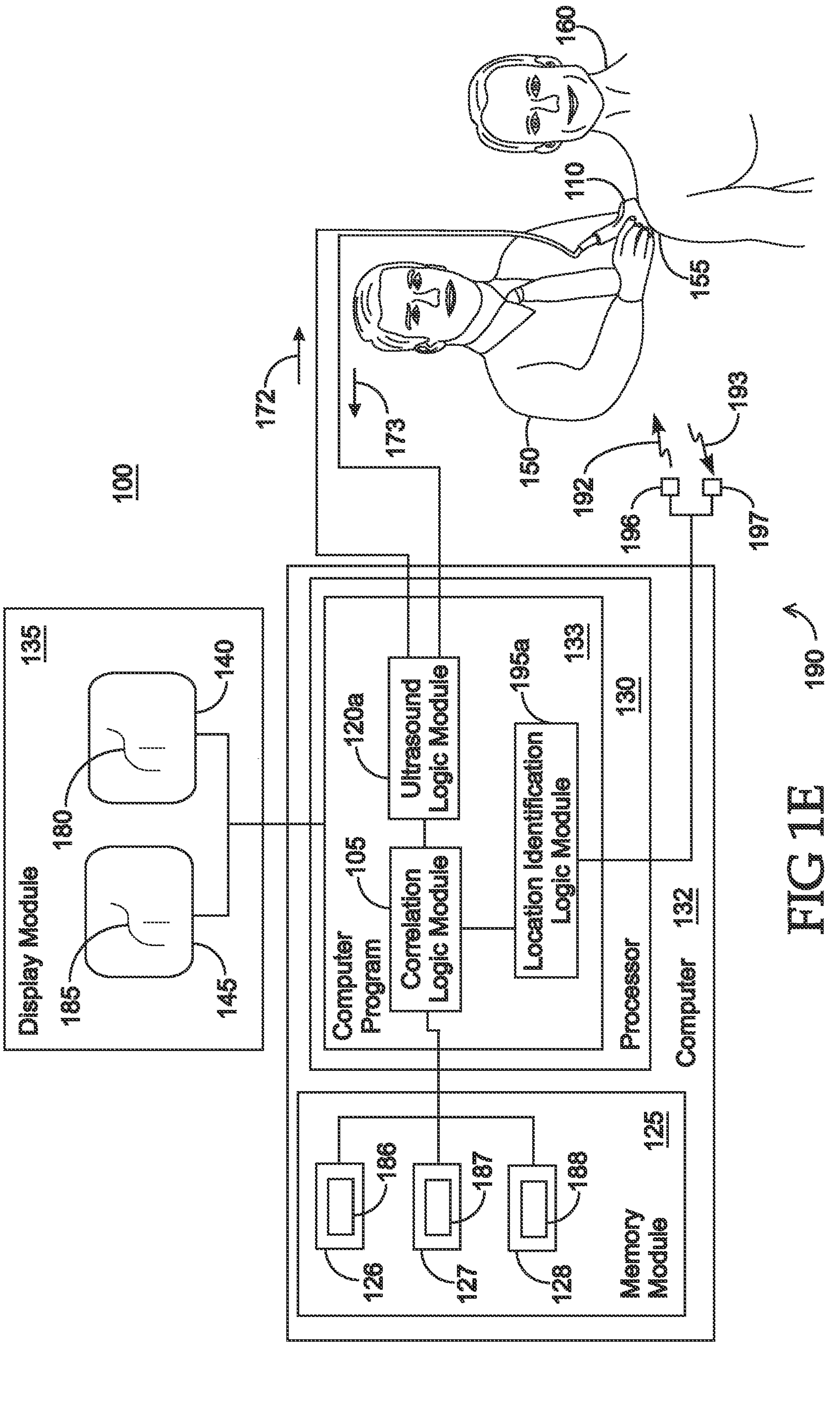
Display Module
135
185
145
180
140
Processor
130
Correlation Logic Module
105
Ultrasound Logic Module
120a
Location Identification Logic Module
195a
132
Computer
Memory Module
125
126
186
127
187
128
188
172
173
150
110
155
160
192
193
196
197
190

FIG 1D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Display Module
135
185
145
180
140
Computer Program
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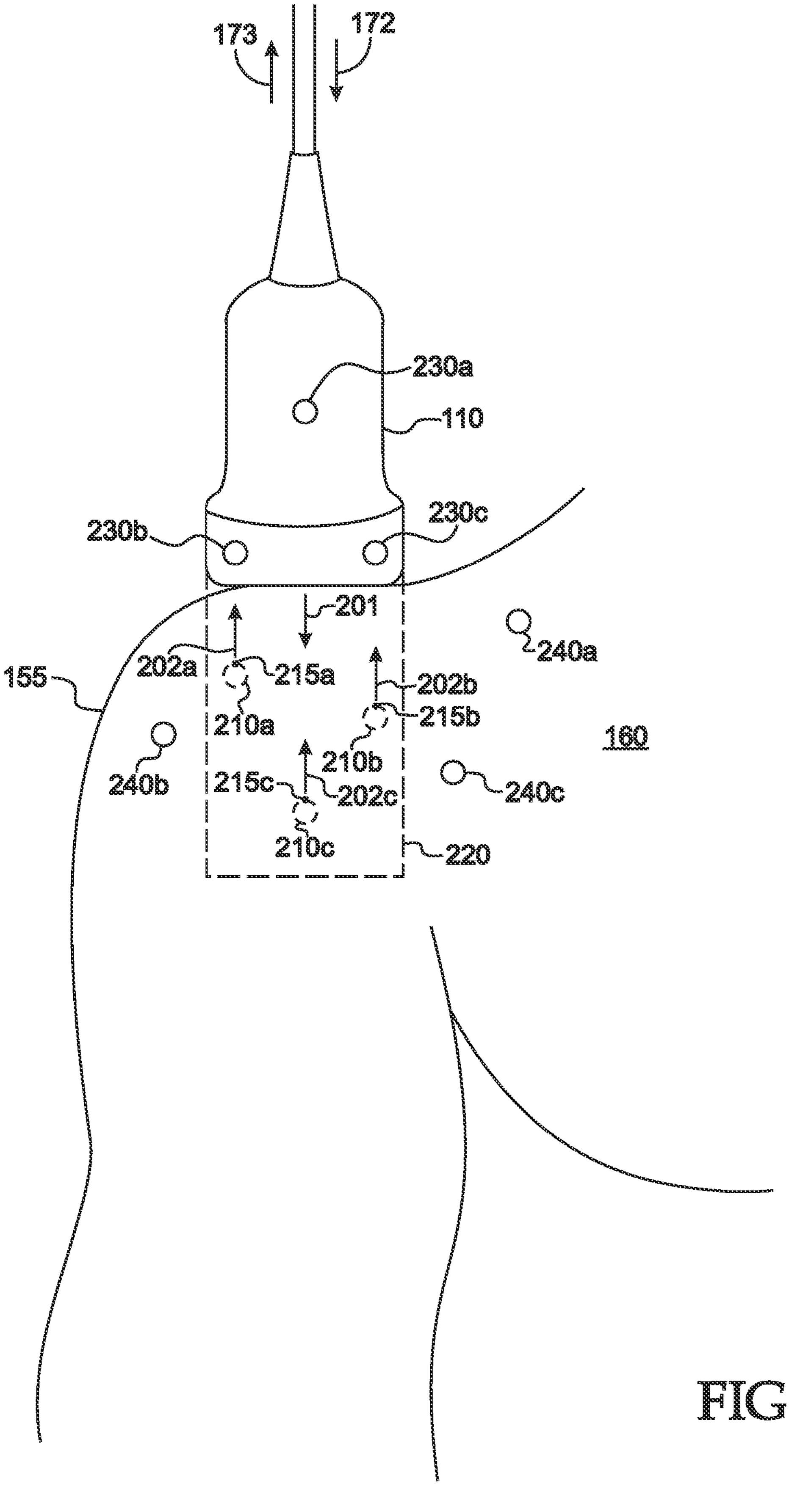
Correlation Logic Module
120a
Ultrasound Logic Module
195a
Location Identification Logic Module
133
130
Processor
Computer
132
Memory Module
125
126
127
128
186
187
188
172
173
150
110
155
160
192
193
196
197
190

FIG 1E


173
172
230a
110
230b
230c
201
240a
202a
215a
155
202b
215b
210a
160
210b
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202c
240c
210c
220

FIG 2

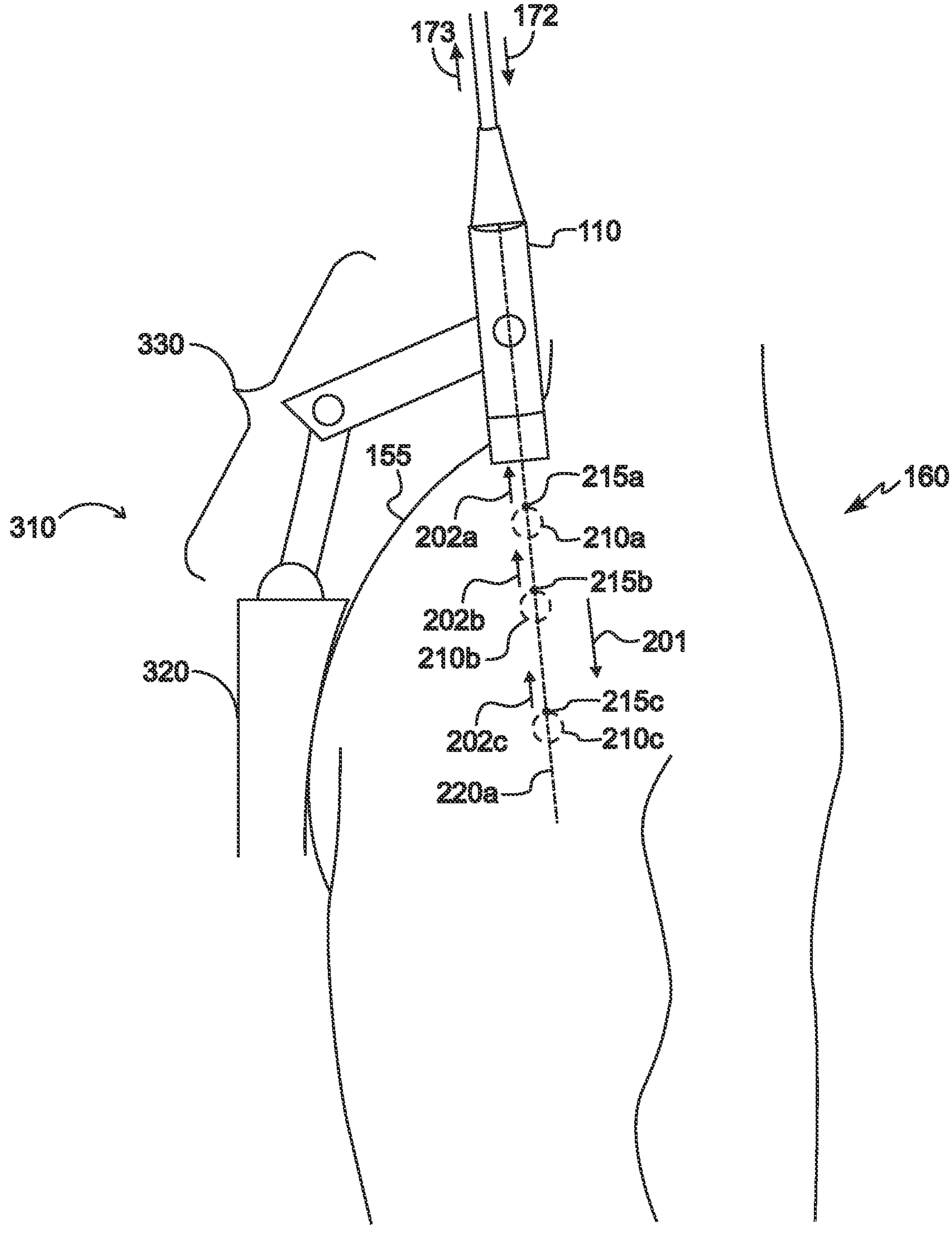
173
172
110
330
155
215a
160
310
202a
210a
215b
202b
201
210b
320
215c
202c
210c
220a

FIG 3

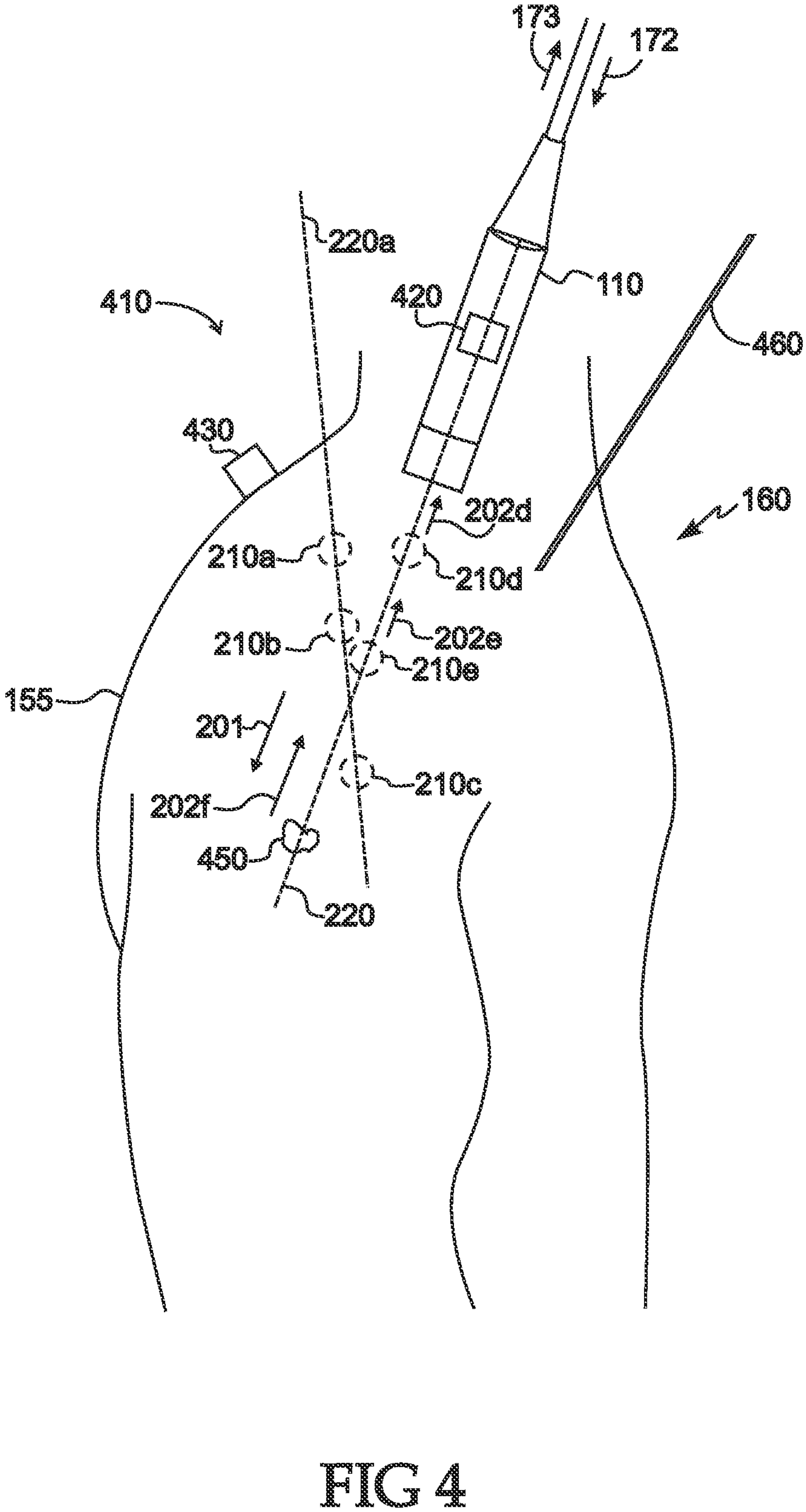
173
172
220a
110
410
420
460
430
160
202d
210a
210d
210b
202e
210e
155
201
210c
202f
450
220

FIG 4

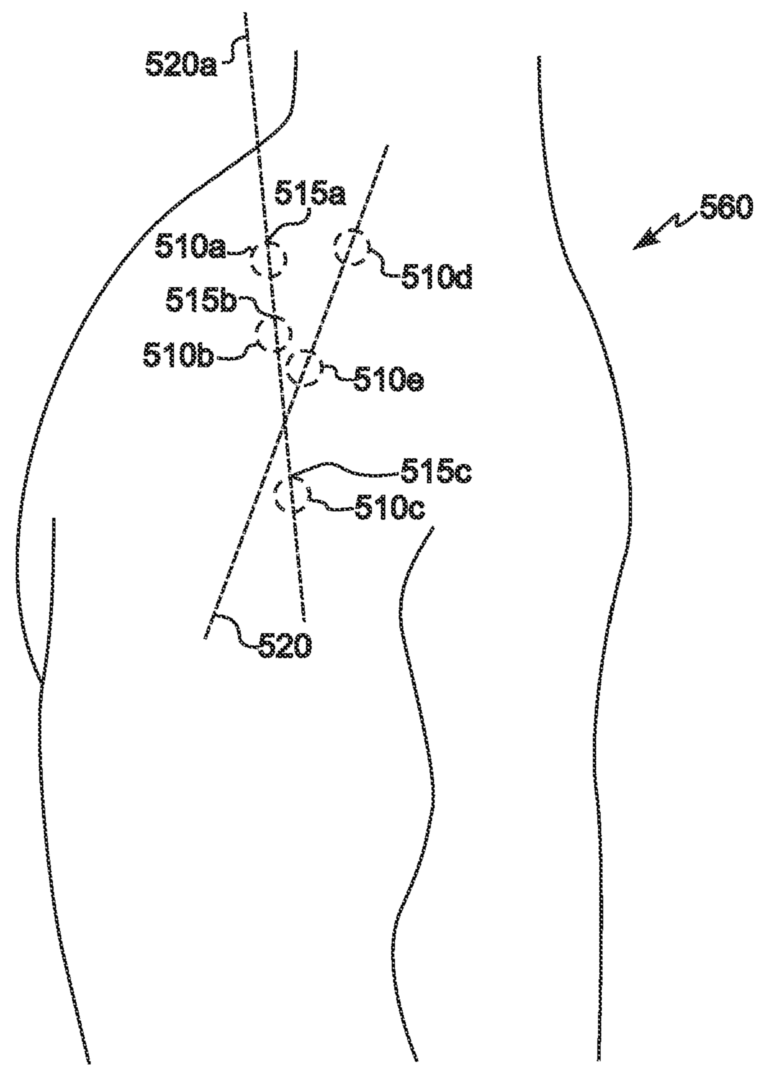

FIG 5

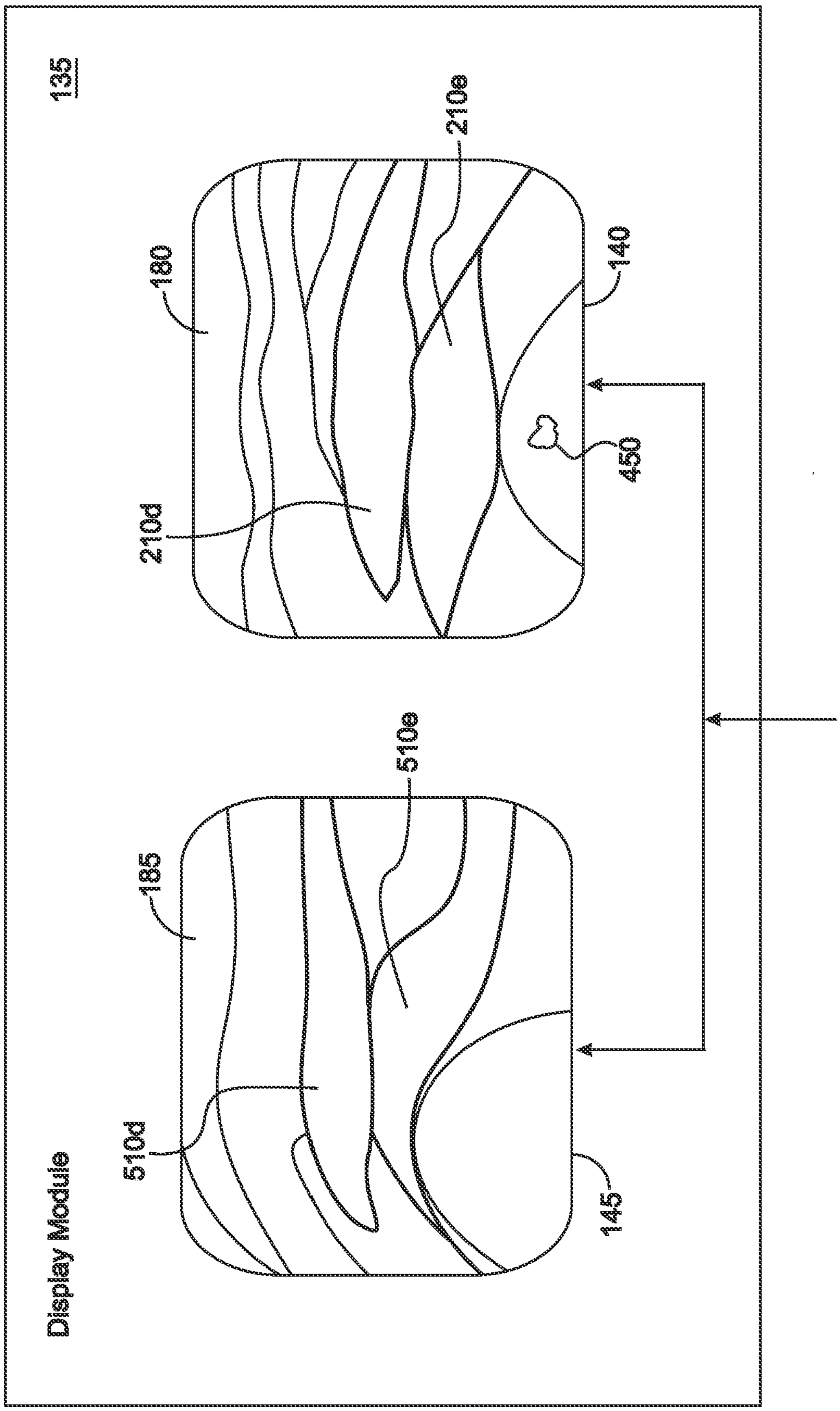

FIG 6

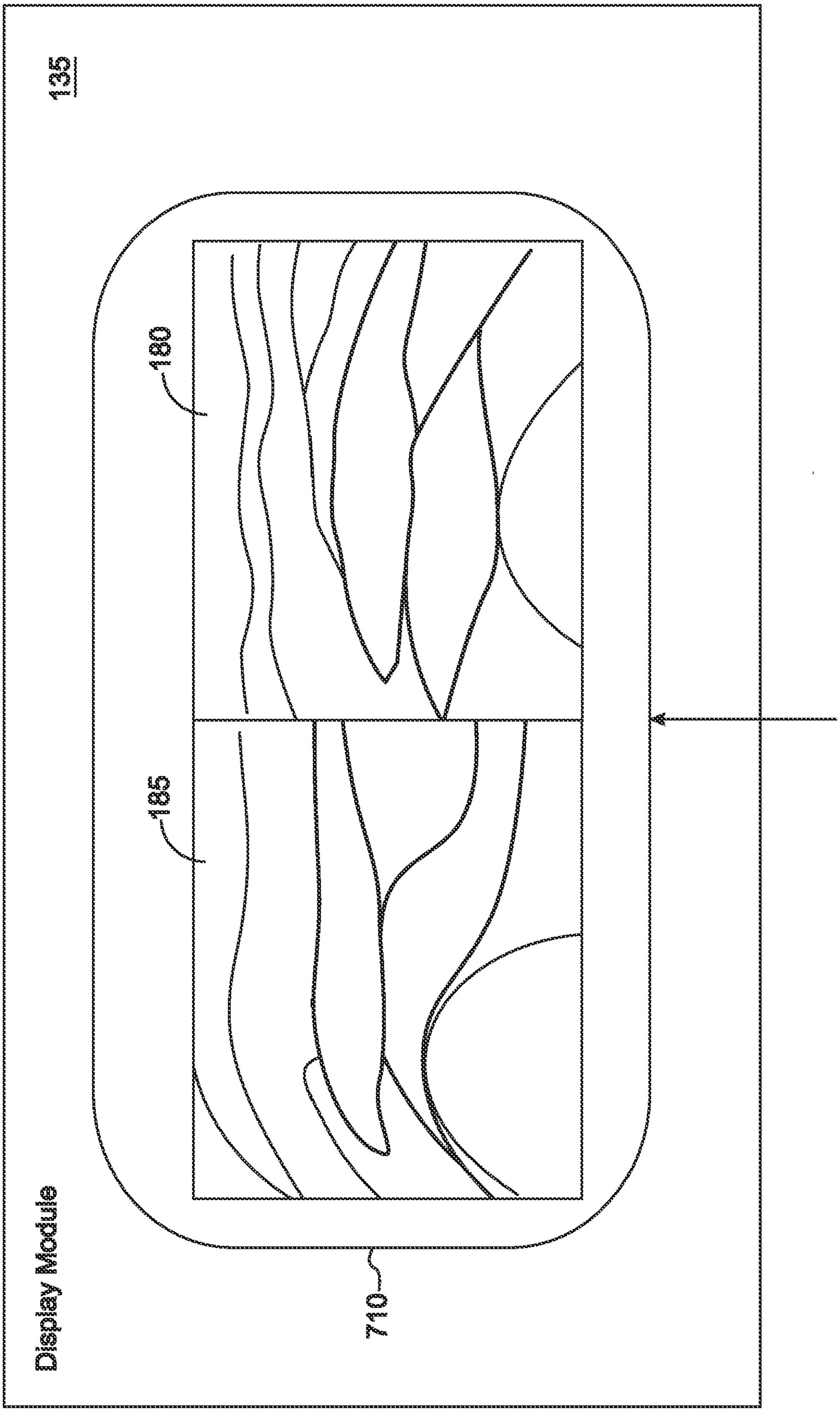

FIG 7

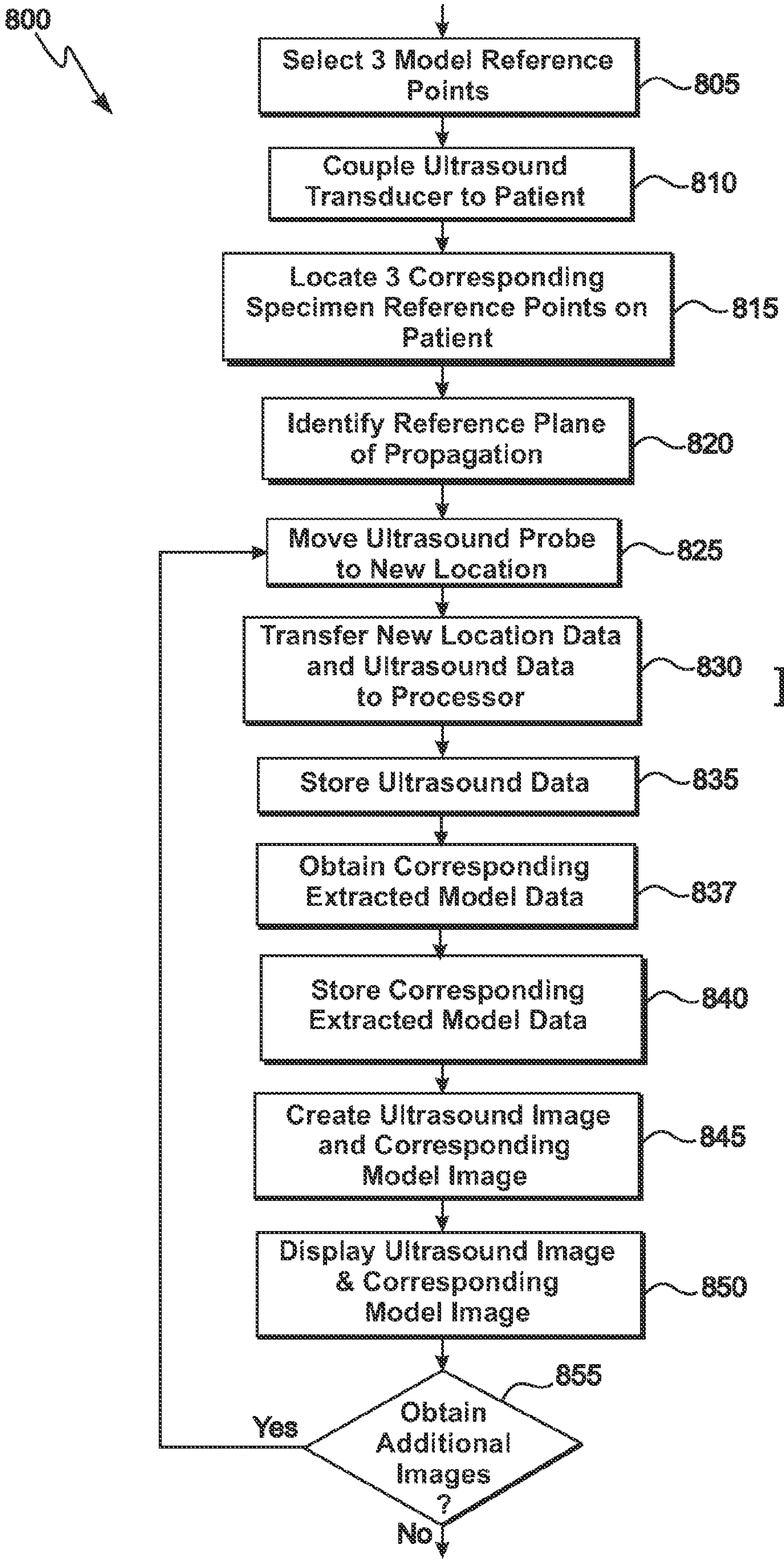
800
Select 3 Model Reference Points
805
Couple Ultrasound Transducer to Patient
810
Locate 3 Corresponding Specimen Reference Points on Patient
815
Identify Reference Plane of Propagation
820
Move Ultrasound Probe to New Location
825
Transfer New Location Data and Ultrasound Data to Processor
830
Store Ultrasound Data
835
Obtain Corresponding Extracted Model Data
837
Store Corresponding Extracted Model Data
840
Create Ultrasound Image and Corresponding Model Image
845
Display Ultrasound Image & Corresponding Model Image
850
855
Obtain Additional Images ?
Yes
No

FIG 8

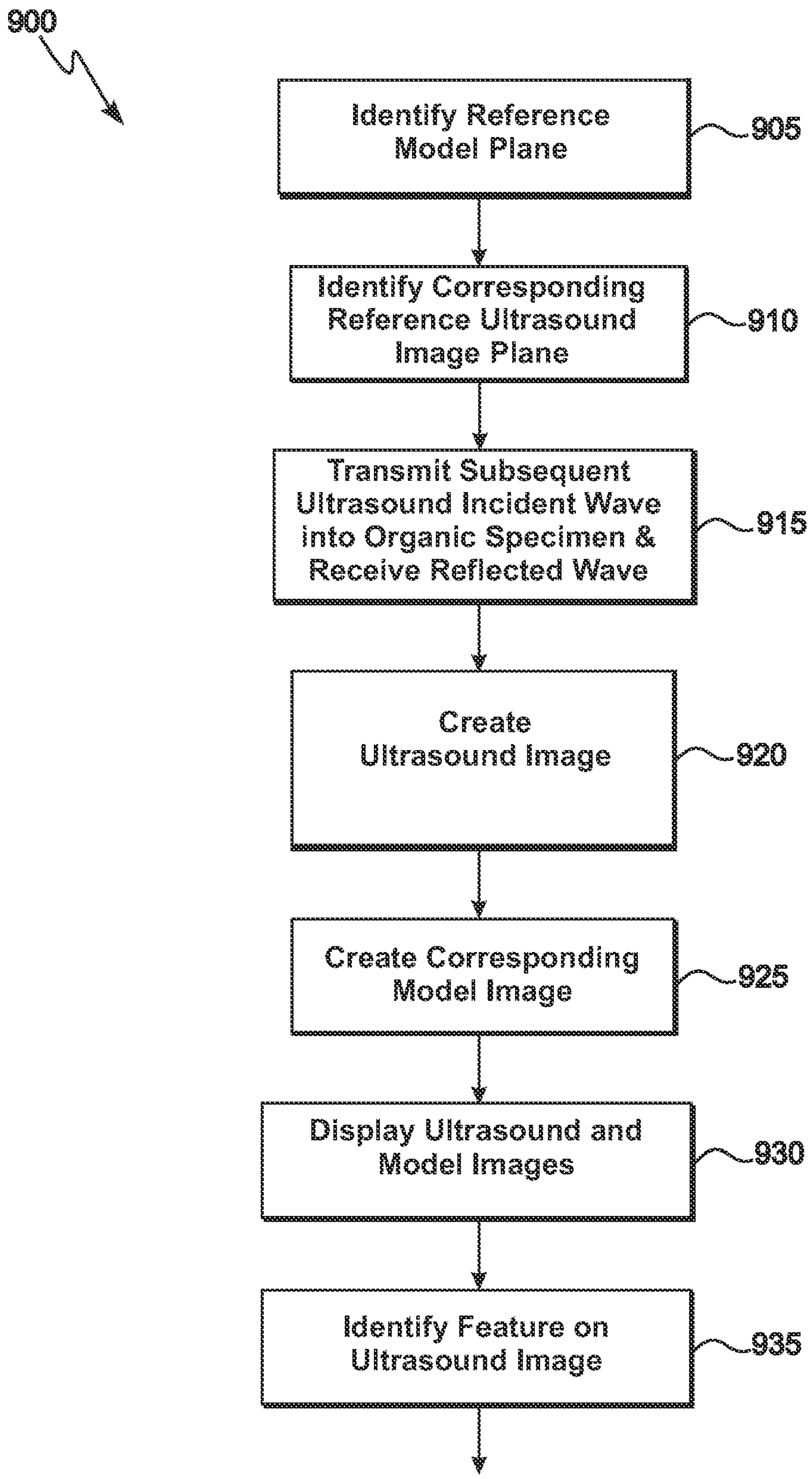
900
Identify Reference Model Plane
905
Identify Corresponding Reference Ultrasound Image Plane
910
Transmit Subsequent Ultrasound Incident Wave into Organic Specimen & Receive Reflected Wave
915
Create Ultrasound Image
920
Create Corresponding Model Image
925
Display Ultrasound and Model Images
930
Identify Feature on Ultrasound Image
935

FIG 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 18 8980

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2009/036775 A1 (IKUMA SOICHI [JP] ET AL) 5 February 2009 (2009-02-05) * paragraphs [0026], [0027], [0059], [0060], [0065], [0080], [0081], [0101] - [0103], [0106], [0123], [0133], [0148], [0188] * * figures 1,5,6,9,11 * -----	1-14	INV. A61B8/00 G06T7/00 G06T19/00

TECHNICAL FIELDS SEARCHED (IPC)

A61B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 November 2018	Willig, Hendrik

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 18 8980

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-11-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009036775 A1	05-02-2009	EP 2020203 A2	04-02-2009
		JP 5394622 B2	22-01-2014
		JP 2009034225 A	19-02-2009
		US 2009036775 A1	05-02-2009

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	超声图像中有机标本特征识别的方法和装置		
公开(公告)号	[EP3434191A1](EP3434191A1)	公开(公告)日	2019-01-30
申请号	EP2018188980	申请日	2012-06-15
[标]申请(专利权)人(译)	GRONSETH悬崖 托比John发		
申请(专利权)人(译)	GRONSETH，悬崖，A. 托比，约翰E.		
当前申请(专利权)人(译)	GRONSETH，悬崖，A. 托比，约翰E.		
[标]发明人	GRONSETH CLIFF A TOBEY JOHN E		
发明人	GRONSETH, CLIFF, A. TOBEY, JOHN, E.		
IPC分类号	A61B8/00 G06T7/00 G06T19/00		
CPC分类号	A61B8/4209 A61B8/4218 A61B8/4245 A61B8/463 A61B8/464 A61B8/466 A61B8/483 A61B8/5223 A61B8/5238 G16H50/30 Y10S128/903 Y10S128/904 A61B8/13 A61B8/4263		
优先权	13/135350 2011-07-01 US 13/270120 2011-10-10 US PCT/US2012/042760 2012-06-15 WO		
外部链接	Espacenet		

摘要(译)

装置[100]，方法[900]和非暂时性计算机可读介质[125]。装置[100]包括处理器[130]，其配置用于从超声反射波[202]接收超声数据[187]，获得对应于有机样本[160]的至少一部分[155]的解剖模型数据[186]，利用解剖模型数据[186]中的配对等效标本特征[210]，识别解剖模型[186]中的参考模型图像区域[520a]和有机标本[160]中的对应参考传播区域[220a];并在超声数据[187]。超声波反射波[202]是由超声波入射波[201]通过有机样本中的样本特征[210] [160]引起的。保持每个超声反射波[202]相对于有机样本[160]的位置感知。

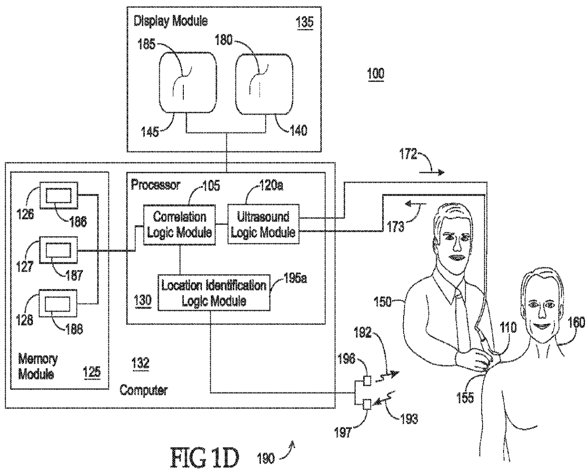

FIG 1D