



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.05.2019 Bulletin 2019/20

(51) Int Cl.:
A61B 8/08 (2006.01) **A61B 8/12 (2006.01)**
A61B 8/00 (2006.01) **A61B 18/00 (2006.01)**
A61N 1/00 (2006.01)

(21) Application number: **17201547.1**

(22) Date of filing: **14.11.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
MA MD

- **KOLEN, Alexander Franciscus**
5656 AE Eindhoven (NL)
- **BELT, Harm Jan Willem**
5656 AE Eindhoven (NL)
- **HARKS, Godefridus Antonius**
5656 AE Eindhoven (NL)

(71) Applicant: **Koninklijke Philips N.V.**
5656 AE Eindhoven (NL)

(74) Representative: **de Haan, Poul Erik et al**
Philips International B.V.
Philips Intellectual Property & Standards
High Tech Campus 5
5656 AE Eindhoven (NL)

(72) Inventors:
 • **GIJSBERS, Gerardus Henricus Maria**
5656 AE Eindhoven (NL)

(54) **ULTRASOUND TRACKING AND VISUALIZATION**

(57) The invention relates to an ultrasound visualization system 111, 311 for tracking a position of an interventional device 112 based on a stream of live ultrasound images 113. A processor 117 receives the stream of live ultrasound images 113, extracts a reference image 118 that includes an anatomical feature 119, extracts from the stream of live ultrasound 113 images a current image 120 that includes a portion of the anatomical feature 119 and a portion of the interventional device 112 at a current

position 121, matches the portion of the anatomical feature in the current image 120 with the anatomical feature in the reference image 118 to determine a spatial relationship between the current position of the interventional device and the anatomical feature in the reference image 118, and indicates, in the reference image 118, the current position 121 of the interventional device 112, based on the determined spatial relationship.

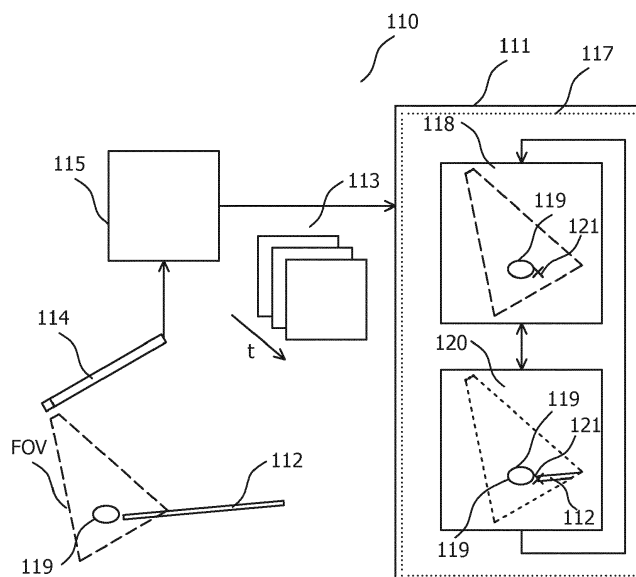


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The invention relates to an ultrasound visualization system for tracking a position of an interventional device based on a stream of live ultrasound images of an ultrasound imaging probe. A computer program product is also disclosed. The invention may be used in the medical ultrasound imaging field, and more specifically in ultrasound-based cardiac imaging. The stream of live ultrasound images may exemplarily be provided by a cardiac imaging probe such as an intra cardiac echo, ICE, probe or a trans esophageal echocardiogram, TEE, probe. The interventional device may for example be an ablation catheter.

BACKGROUND OF THE INVENTION

[0002] Interventional cardiology procedures such as the treatment of cardiac arrhythmias by catheter ablation are increasingly using tracking and mapping techniques to navigate interventional devices within the body. The treatment of atrial fibrillation by catheter ablation is an example of such a procedure. In this, an ablation catheter is used to deliver energy to the cardiac wall to destroy living tissue in order to stop undesired conduction of electric pulses that cause the arrhythmia. Catheter navigation and mapping systems such as Carto, produced by Biosense-Webster, and Ensite, produced by St. Jude Medical are routinely used in this procedure to guide the catheter to the treatment site. These known systems typically use magnetic fields and impedance sensing to respectively navigate the interventional device and to perform cardiac mapping.

[0003] A drawback of some cardiac navigation systems is their limited ability to visualize cardiac tissue, particularly the cardiac wall. The known systems typically create a virtual 3D model of the targeted anatomy in which the tracked ablation catheter is graphically visualized. The lack of visualization of the anatomy is often compensated-for by using additional X-ray, typically fluoroscopic, imaging to verify the catheter's location. The poor visualization of soft tissue under X-ray typically requires the physician to undergo extensive training in order to be able to correctly determine the catheter position in the fluoroscopic image. In order improve the visualization of cardiac tissue, ultrasound imaging systems such as 2D intra cardiac echography, ICE, are increasingly being used in these procedures. However it can still be difficult to follow the treatment catheter's movements in the ultrasound image.

[0004] US patent 8,303,505 B2 describes an apparatus for image guidance and documentation of medical procedures. One embodiment includes combining small field of view images into a recorded image of with a large field of view and aligning the small field of view real time image with the recorded image through correlation of im-

aging data. A location and orientation determination system may be used to track the imaging system and provide a starting set of image alignment parameters and/or provide change updates to a set of image alignment parameters, which is then further improved through correlating imaging data. The recorded image may be selected according to real time measurement of a cardiac parameter during an image guided cardiac procedure.

[0005] However a need exists for improved anatomical visualization during cardiac, and other interventional medical procedures. There is also a need to reduce the X-ray imaging dose to a patient during such procedures.

SUMMARY OF THE INVENTION

[0006] The invention seeks to improve anatomical visualization during medical procedures. The invention also seeks to reduce the X-ray imaging dose to a patient during such procedures. Further advantages from the described invention will be apparent to the skilled person. Thereto an ultrasound visualization system for tracking a position of an interventional device based on a stream of live ultrasound images of an ultrasound imaging probe, is provided. The ultrasound visualization system comprises at least one processor configured to: i) receive the stream of live ultrasound images; ii) extract from the stream of live ultrasound images a reference image comprising reference image data, the reference image including an anatomical feature; iii) extract from the stream of live ultrasound images a current image comprising current image data, the current image being later in time to the reference image and including at least a portion of the anatomical feature and including at least a portion of the interventional device at a current position; iv) match the at least a portion of the anatomical feature in the current image with the anatomical feature in the reference image to determine a spatial relationship between the current position of the interventional device and the anatomical feature in the reference image; and v) indicate, in the reference image, the current position of the interventional device, based on the determined spatial relationship.

[0007] The use of ultrasound imaging in the system improves the visualization of soft tissue. Moreover, since the reference image, or "map", is generated from the stream of live ultrasound images, a benefit of the ultrasound visualization system in relation to known tracking systems that generate an anatomical map in a pre-procedural imaging stage includes the obviation of the need to perform two separate medical procedures. Also, since the map is generated from the live ultrasound image stream, it is more up-to-date than a map that is generated a pre-procedural imaging stage. Moreover, the extracted reference image is inherently static, and so any movement of the ultrasound probe after the generation of this "map" is not translated into a movement of the map. This, in combination with indicating the live position of the interventional device in the static map, allows a user of the

system to more easily direct the interventional device to an anatomical feature in the map. Also, the X-ray dose to a patient during such a procedure may also be reduced, or even not required, because the ultrasound reference image provides sufficient positioning information of the interventional device in relation to the anatomical feature.

[0008] According to one aspect the field of view of the reference image is extended. In this aspect the reference image corresponds to a first field of view, and the current image corresponds to a second field of view that has as an overlapping portion that overlaps with the first field of view and a non-overlapping portion that does not overlap with the first field of view. The at least one processor is further configured to extend the field of view of the reference image by: i) matching the at least a portion of the anatomical feature in the current image with the anatomical feature in the reference image to establish a spatial relationship between the non-overlapping portion of the second field of view and the first field of view; and ii) adapting the reference image to include at least a portion of the non-overlapping portion of the second field of view based on the established spatial relationship. The extended field of view of the reference image therefore includes more anatomical information. During the medical procedure, movements of the ultrasound transducer, for example from heart contractions or from patient breathing, cause changes in the field of view of the current image as compared to that of the reference image. In this aspect the non-overlapping field of view, is used to extend the map. Improved navigation of the interventional device is provided through the ability to track the interventional device over a larger anatomical region. Moreover, the ability to generate such an extended map from the live images means that a more extensive up-to-date map can be generated during a medical procedure. This provides improved guidance because the interventional device can be more accurately guided to a treatment site.

[0009] According to another aspect the at least one processor is further configured to: i) receive from the interventional device a trigger signal indicative of an activation of the interventional device; and to ii) provide a marker in the reference image corresponding to the position of the interventional device at the time at which the interventional device was activated. In so doing, the reference image, i.e. the map, may be used to record anatomical sites where a medical intervention such as the delivery of a therapeutic treatment or the removal of tissue or a measurement of tissue properties has taken place within the anatomy. In one example this aspect may be used to record ablation positions of an ablation catheter that serves as the interventional device. Again, since the map is static, improved navigation is provided by a user's ability to more clearly see anatomical regions where an ablation has taken place.

[0010] According to another aspect the at least one processor is further configured to: i) receive, from a positioning system comprising at least one position sensor

disposed on the interventional device, and at least one position sensor disposed on the ultrasound imaging probe, position data corresponding to a current position of the position sensor disposed on the interventional device respective the ultrasound imaging probe; and to ii) indicate, in the reference image, the current position of the interventional device, based further on the current position of the position sensor disposed on the interventional device respective the ultrasound imaging probe. This aspect may be useful in more accurately positioning the interventional device in the reference image, particularly when the interventional device is located toward the edge of the field of view of the ultrasound imaging probe and where image resolution may be degraded.

[0011] Further aspects of the invention are described with reference to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 illustrates an arrangement 110 that includes an ultrasound visualization system 111.

Fig. 2 illustrates an exemplary application in which ultrasound visualization system 111 is used to image a pulmonary vein ostium 222.

Fig. 3 illustrates an arrangement 310 that includes an ultrasound visualization system 111 wherein the field of view of reference image 118 is extended.

DETAILED DESCRIPTION OF EMBODIMENTS

[0013] In order to illustrate the principles of the present invention an ultrasound visualization system is described with particular reference to a cardiac ablation procedure in which an ICE imaging probe serves as the ultrasound imaging probe, and in which an ablation catheter serves as the interventional device. It is however to be appreciated that the invention also finds application in the wider ultrasound imaging field. The ultrasound imaging probe may alternatively be for example a TEE imaging probe, and the interventional device may for example be a catheter, an ablation catheter, an ablation support catheter, a biopsy device, a guidewire, a filter device, a balloon device, a stent, a mitral clip, a left atrial appendage closure device, an aortic valve, a pacemaker lead, an intravenous line, or a surgical tool.

[0014] Fig. 1 illustrates an arrangement 110 that includes an ultrasound visualization system 111. Arrangement 110 may be used to track a position of interventional device 112, such as an ablation catheter, based on a stream of live ultrasound images 113 that are provided by an ultrasound imaging probe 114 that is exemplified by an ICE imaging probe having a field of view FOV. Arrangement 110 in Fig. 1 is illustrated as including ultrasound imaging probe console 115 which is configured to receive data from ultrasound imaging probe 114 and to convert said data into a stream of live ultrasound im-

ages 113 that are transmitted to ultrasound visualization system 111. Ultrasound imaging probe console 115 may include one or more processors configured to provide this functionality. Ultrasound imaging probe 114 is illustrated as being connected to ultrasound imaging probe console 115, and ultrasound imaging probe console 115 is illustrated as being connected to ultrasound visualization system 111, by means of wired interconnections. However, wireless connections for one or more of these connections are also contemplated. Moreover, it is also contemplated that some or all of the functionality of ultrasound imaging probe console 115 may be included in the ultrasound imaging probe 114 or in ultrasound visualization system 111.

[0015] Ultrasound visualization system 111 includes at least one processor 117. As described above, the at least one processor may perform some or all of the processing described in relation to the ultrasound imaging probe console 115. Ultrasound visualization system 111 includes at least one processor 117 that is configured to: i) receive the stream of live ultrasound images 113; ii) extract from the stream of live ultrasound images 113 a reference image 118 comprising reference image data, the reference image including an anatomical feature 119; iii) extract from the stream of live ultrasound images 113 a current image 120 comprising current image data, the current image 120 being later in time to the reference image 118 and including at least a portion of the anatomical feature 119 and including at least a portion of the interventional device 112 at a current position 121; iv) match the at least a portion of the anatomical feature in the current image 120 with the anatomical feature in the reference image 118 to determine a spatial relationship between the current position of the interventional device and the anatomical feature in the reference image 118; and to v) indicate, in the reference image 118, the current position 121 of the interventional device 112, based on the determined spatial relationship. In so doing the current, i.e. live, position of the interventional device is provided in the reference image.

[0016] Stream of live ultrasound images 113 may be either 2D or 3D ultrasound images. In a particular example the images are 3D ultrasound images from an ICE imaging probe. Interventional device 112 may in general be any interventional device. In a particular example, interventional device 112 is an ablation catheter. Anatomical feature 119 in reference image 118 may be any anatomical feature that is discernible in an ultrasound image. In the specific example of cardiac ablation it may for example correspond to part of a pulmonary vein ostium. Current image 120 may be in general be any image from the stream of live ultrasound images 113 that is later in time to the reference image. Owing to the live nature of the stream, current image 120 is continually replaced in time by the latest image. Optionally, reference image 218 may be periodically updated. It may be useful to generate a more up-to-date reference image that reflects recent anatomical changes, or for example when the ultra-

sound probe is moved to a new position of the interventional device within the anatomy.

[0017] In one implementation the step of extracting current image 120 from the stream of live ultrasound images 113, may include determining the current position of the interventional device by performing an edge detection method on the current image data to determine an outline of the interventional device. Suitable known edge detection methods include frequency domain filtering and Fourier transformations.

[0018] The step of matching the at least a portion of the anatomical feature in the current image 120 with the anatomical feature in the reference image 118 to determine a spatial relationship may be performed by one of many known image processing algorithms. Scale-invariant feature transform, SIFT, is one suitable example. Rigid or non-rigid image transforms known from the medical image processing field may also be used. The correlation technique described in US patent 5,655,535, or the real-time image alignment procedure described in US patent 8,303,505 may alternatively be used. The spatial relationship may be in 2D image space or in 3D image space and may for example be a translation or a rotation or a combination of a rotation and a translation. The spatial relationship may for example be represented as a vector in Cartesian or polar coordinates.

[0019] The step of indicating, in the reference image 118, the current position 121 of the interventional device 112, may include for example positioning a marker such as a cross, a circle or other shape, a point, an outline of the interventional device, or locally changing the color, saturation, or hue of a pixel in the reference image.

[0020] Fig. 2 illustrates an exemplary application in which ultrasound visualization system 111 is used to image a pulmonary vein ostium 222. In Fig. 2a, 3D ICE catheter serving as ultrasound imaging probe 214 is arranged within the heart to view pulmonary vein ostium 222. Interventional device 212, such as a cardiac ablation catheter, is also disposed within the field of view FOV of 3D ICE catheter 214. In Fig. 2b a live stream of ultrasound images 213 of pulmonary vein ostium 222 is illustrated. Reference image 218 is extracted from live stream 213 and includes pulmonary vein ostium 222. Thereafter, reference image 218 serves as a map in which the current, i.e. the most recent, position of the 3D ICE catheter is indicated. The current ultrasound image 220 from live stream 213 includes interventional device 212 at current position 221. Current position 221 of interventional device 212 is subsequently indicated in reference image 218 in the form of exemplary cross 221.

[0021] Optionally, reference image 218 in Fig. 2b may be periodically updated. It may be useful to generate a more up-to-date reference image that reflects recent anatomical changes, or for example when the ultrasound probe is moved to a new position within the anatomy.

[0022] In one embodiment illustrated in Fig. 2c, interventional device 212 may be capable of being activated, and a marker may be inserted in reference image 218 at

the activation position each time a trigger signal corresponding to the activation is received by the ultrasound visualization system. The marker may be displayed for a time period after the activation in order to provide a record of the activation positions. Continuing with the example in which the interventional device is an ablation catheter, the marker positions, and therefore the trigger signals may correspond to positions at which ablation energy is delivered by the ablation catheter. Thereto, in Fig. 2c the evolution of reference image 218 is illustrated in the case when an ablation catheter serving as interventional device 212 at current positions 221 in pulmonary vein ostium 222 is activated multiple times. Each time interventional device 212 is activated, a marker 223_{1..n} is provided in reference image 218. Marker 223 is illustrated as an exemplary circle and may in general indicate the positions of activation of other interventional devices described herein, such as the activation position of a biopsy device, image positions of a second imaging catheter, tissue measurement positions, the deployment position of a stent activator, and so forth. Other marker shapes may alternatively be used for marker 223.

[0023] In operation the functionality described with reference to Fig. 2 may be provided by the system processor described with reference to Fig. 1. Thereto, the processor of Fig. 1 may additionally be configured to: i) receive from the interventional device a trigger signal indicative of an activation of the interventional device; and to ii) provide a marker in the reference image corresponding to the position of the interventional device at the time at which the interventional device was activated.

[0024] In one embodiment that is described with reference to Fig. 3, the field of view of reference image 118 may optionally be extended. Fig. 3 illustrates an arrangement 310 that includes an ultrasound visualization system 311 wherein the field of view of reference image 118 is extended. In Fig. 3 reference image 118 corresponds to first field of view 331, and current image 120 corresponds to second field of view 332. Second field of view 332 has an overlapping portion 332a that overlaps with the first field of view 331 and a non-overlapping portion 332b that does not overlap with the first field of view 331. In addition to the functionality described in relation to Fig. 1, processor 117 in Fig. 3 is further configured to extend the field of view of reference image 118 by: i) matching the at least a portion of the anatomical feature 119 in current image 120 with the anatomical feature 119 in reference image 118 to establish a spatial relationship between the non-overlapping portion of the second field of view 332b and the first field of view 331; and ii) adapting reference image 118 to include at least a portion of the non-overlapping portion of the second field of view 332b based on the established spatial relationship.

[0025] In Fig. 3 a 2D ultrasound imaging probe 114 is illustrated, however the principles of this embodiment apply equally to a 3D ultrasound imaging probe. Two fields of view 331, 332, are illustrated in Fig. 3. Reference image 118 corresponds to first field of view 331 and current

image 120 corresponds to second field of view 332. In Fig. 3, different fields of view 331, 332 are provided by a relative movement between the ultrasound imaging probe and the anatomy. Such a relative movement may be inherent in any medical imaging procedure and caused for example by natural movements of the anatomy, such as contractions of the heart or breathing, or alternatively by a user moving ultrasound imaging probe 114. Different fields of view 331, 332 may also be provided by scanning the field of view of the ultrasound imaging probe. Known beamforming techniques may be used to provide such scanning and may involve adjusting the relative delays between the ultrasound beams transmitted and/or received by ultrasound imaging probe 114. In either situation, second field of view 332 has as an overlapping portion 332a that overlaps with the first field of view 331 and a non-overlapping portion 332b that does not overlap with the first field of view 331.

[0026] The same matching procedures as described above in relation to Fig. 1 may be used to establish a spatial relationship between the non-overlapping portion of the second field of view 332b and the first field of view 331. Particular emphasis may be made on the matching procedure at the boundary between the non-overlapping portion of the second field of view 332b and the first field of view 331 in order to provide a seamless transition between the two regions.

[0027] The step of adapting the reference image 118 may include using part or all of the image data from the non-overlapping portion of the second field of view 332b to update the reference image, thereby extending it. The adaptation therefore results in an effective field of view that is less than or equal to the combination of fields of views 331, 332 in Fig. 3. Advantageously the extended reference image provides a larger region within which the interventional device can be tracked.

[0028] Optionally, in the embodiment of Fig. 3 the step of adapting the reference image may further include using current image data from at least a portion of the overlapping portion of the second field of view 332a to update a corresponding portion of the reference image 118. In other words the reference image may be updated in specific regions in order to reflect recent changes in the anatomy since reference image 118 was extracted from the stream of live ultrasound images. This may be useful for example during an ablation procedure in order to visually determine the extent of an ablation procedure. The updating may for example include averaging the current image data and the reference image data at corresponding positions within the overlapping portion of the second field of view 332a. This averaging may also act so to denoise the reference image, i.e. to improve image quality. Alternatively the reference image data may be entirely replaced by the current image at corresponding positions, or the reference image may be overlaid by the current image at corresponding positions.

[0029] In another embodiment, either of the systems described with reference to Fig. 1 or Fig. 3 may be aug-

mented by an additional positioning system that provides position data corresponding to a current position of the position sensor disposed on the interventional device respective the ultrasound imaging probe. This additional position data may be used to improve the positioning accuracy of the system, for example when the interventional device is located in low signal-to-noise ratio region of the current image in the stream of live ultrasound image. The additional positioning system may for example be an ultrasound-based positioning system such as that described in document WO 2011/138698A1 and in the publication "A New Sensor Technology for 2D Ultrasound-Guided Needle Tracking", Huanxiang Lu et al, MICCAI 2014, Part II, LNCS 8674, pp. 389-396, 2014, or a fiberoptic shape-sensing-based positioning system such as that described in US patent 8,050,523 B2, or a magnetic-based positioning system, or an electromagnetic-based positioning system such as that described in US patent 6,233,476 B1. Such positioning systems conventionally employ a position sensor on the interventional device. Thereto, processor 117 of Fig. 1 or Fig. 2 may additionally be configured to: i) receive, from a positioning system comprising at least one position sensor disposed on the interventional device, and at least one position sensor disposed on the ultrasound imaging probe, position data corresponding to a current position of the position sensor disposed on the interventional device respective the ultrasound imaging probe; and to ii) indicate, in the reference image, the current position of the interventional device, based further on the current position of the position sensor disposed on the interventional device respective the ultrasound imaging probe.

[0030] One or more of the method steps disclosed herein, particularly those described in relation to the processor of ultrasound visualization system 111, 211 may be recorded in the form of instructions which when executed on a processor cause the processor to carry out such method steps. The computer program product may be provided by dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor "DSP" hardware, read only memory "ROM" for storing software, random access memory "RAM", non-volatile storage, etc. Furthermore, embodiments of the present invention can take the form of a computer program product accessible from a computer-usable or computer-readable storage medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable storage medium can be any apparatus that may include, store, communicate, propagate, or

transport the program for use by or in connection with the instruction execution system, apparatus, or device. The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, or apparatus or device, or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory "RAM", a read-only memory "ROM", a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk - read only memory "CD-ROM", compact disk - read/write "CD-R/W", Blu-Ray™ and DVD.

[0031] In summary, an ultrasound visualization system has been described that tracks a position of an interventional device. The system includes a processor that i) receives a stream of live ultrasound images; ii) extracts from the stream of live ultrasound images a reference image comprising reference image data, the reference image including an anatomical feature; iii) extracts from the stream of live ultrasound images a current image comprising current image data, the current image being later in time to the reference image and including at least a portion of the anatomical feature and including at least a portion of the interventional device at a current position; iv) matches the at least a portion of the anatomical feature in the current image with the anatomical feature in the reference image to determine a spatial relationship between the current position of the interventional device and the anatomical feature in the reference image; and v) indicates, in the reference image, the current position of the interventional device, based on the determined spatial relationship.

Claims

1. Ultrasound visualization system (111, 311) for tracking a position of an interventional device (112) based on a stream of live ultrasound images (113) of an ultrasound imaging probe (114), the ultrasound visualization system (111) comprising at least one processor (117) configured to:

receive the stream of live ultrasound images (113);
 extract from the stream of live ultrasound images (113) a reference image (118) comprising reference image data, the reference image including an anatomical feature (119);
 extract from the stream of live ultrasound images (113) a current image (120) comprising current image data, the current image (120) being later in time to the reference image (118) and including at least a portion of the anatomical feature (119) and including at least a portion of the interventional device (112) at a current position (121);
 match the at least a portion of the anatomical

- feature in the current image (120) with the anatomical feature in the reference image (118) to determine a spatial relationship between the current position of the interventional device and the anatomical feature in the reference image (118); and to indicate, in the reference image (118), the current position (121) of the interventional device (112), based on the determined spatial relationship.
2. The ultrasound visualization system (311) according to claim 1 wherein the reference image (118) corresponds to a first field of view (331), and wherein the current image (120) corresponds to a second field of view (332) that has as an overlapping portion (332a) that overlaps with the first field of view (331) and a non-overlapping portion (332b) that does not overlap with the first field of view (331); and wherein the at least one processor (117) is further configured to extend the field of view of the reference image (118) by:
 - matching the at least a portion of the anatomical feature in the current image (120) with the anatomical feature in the reference image (118) to establish a spatial relationship between the non-overlapping portion of the second field of view (332b) and the first field of view (331); and adapting the reference image (118) to include at least a portion of the non-overlapping portion of the second field of view (332b) based on the established spatial relationship.
 3. The ultrasound visualization system according to claim 2 wherein adapting the reference image further comprises using current image data from at least a portion of the overlapping portion of the second field of view (332a) to update a corresponding portion of the reference image (118).
 4. The ultrasound visualization system according to claim 3 wherein updating the corresponding portion of the reference image further comprises averaging the current image data and the reference image data at corresponding positions within the overlapping portion of the second field of view (332a).
 5. The ultrasound visualization system according to claim 1 wherein extracting the current image (120) from the stream of live ultrasound images (113) further comprises determining the current position (121) of the interventional device by performing an edge detection method on the current image data to determine an outline of the interventional device (112).
 6. The ultrasound visualization system according to claim 1 or claim 2 further comprising the ultrasound imaging probe (114) and/or the interventional device (112).
 7. The ultrasound visualization system according to claim 6 wherein the ultrasound imaging probe (114) is an intra cardiac echography, ICE, imaging probe or a trans esophageal, TEE, imaging probe.
 8. The ultrasound visualization system according to claim 6 wherein the interventional device (112) is an ablation catheter, an ablation support catheter, or a biopsy device.
 9. The ultrasound visualization system according to claim 1 wherein the at least one processor (117) is further configured to:
 - receive from the interventional device (112) a trigger signal indicative of an activation of the interventional device; and to provide a marker (223) in the reference image (218) corresponding to the position of the interventional device (112) at the time at which the interventional device was activated.
 10. The ultrasound visualization system according to claim 9 wherein the interventional device is an ablation catheter and wherein the trigger signal is indicative of the delivery of ablation energy by the ablation catheter.
 11. The ultrasound visualization system according to any one of claims 1 - 10 wherein the at least one processor (117) is further configured to:
 - receive, from a positioning system comprising at least one position sensor disposed on the interventional device (112), and at least one position sensor disposed on the ultrasound imaging probe (114), position data corresponding to a current position of the position sensor disposed on the interventional device (112) respective the ultrasound imaging probe (114); and to indicate, in the reference image (118), the current position (121) of the interventional device, based further on the current position of the position sensor disposed on the interventional device (112) respective the ultrasound imaging probe (114).
 12. The ultrasound visualization system according to claim 11 wherein the positioning system is one of: an ultrasound-based positioning system, a fiberoptic shape-sensing-based positioning system, a magnetic-based positioning system, or an electromagnetic-based positioning system.

13. The ultrasound visualization system according to claim 11 further comprising the positioning system.

14. Computer program product comprising instructions which, when executed on a processor (117) of an ultrasound visualization system (111, 311) for tracking a position of an interventional device (112) based on a stream of live ultrasound images (113) of an ultrasound imaging probe (114), cause the processor (117) to carry out the method steps of:

- receiving the stream of live ultrasound images (113);
- extracting from the stream of live ultrasound images a reference image (118) comprising reference image data, the reference image (118) including an anatomical feature (119);
- extracting from the stream of live ultrasound images (113) a current image (120) comprising current image data, the current image (120) being later in time to the reference image (118) and including at least a portion of the anatomical feature (119) and including at least a portion of the interventional device (112) at a current position (121);
- matching the at least a portion of the anatomical feature (119) in the current image (120) with the anatomical feature (119) in the reference image (118) to determine a spatial relationship between the current position of the interventional device (112) and the anatomical feature in the reference image (118); and
- indicating, in the reference image (118), the current position (121) of the interventional device (112), based on the determined spatial relationship.

5

10

15

20

25

30

35

40

45

50

55

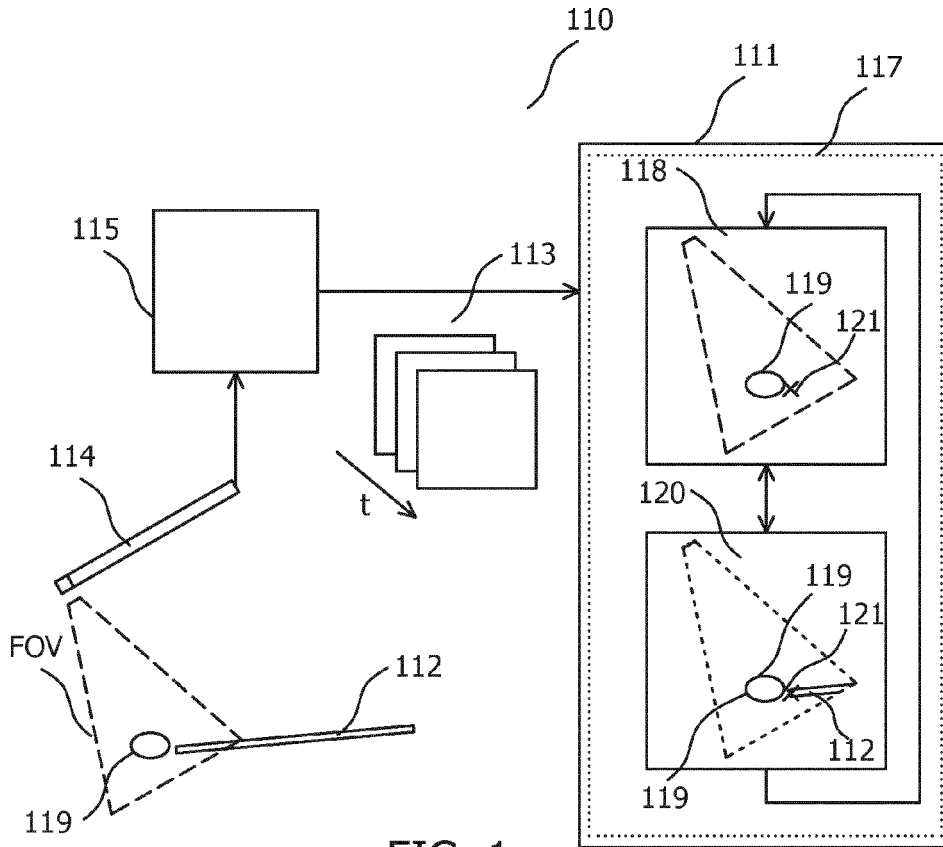


FIG. 1

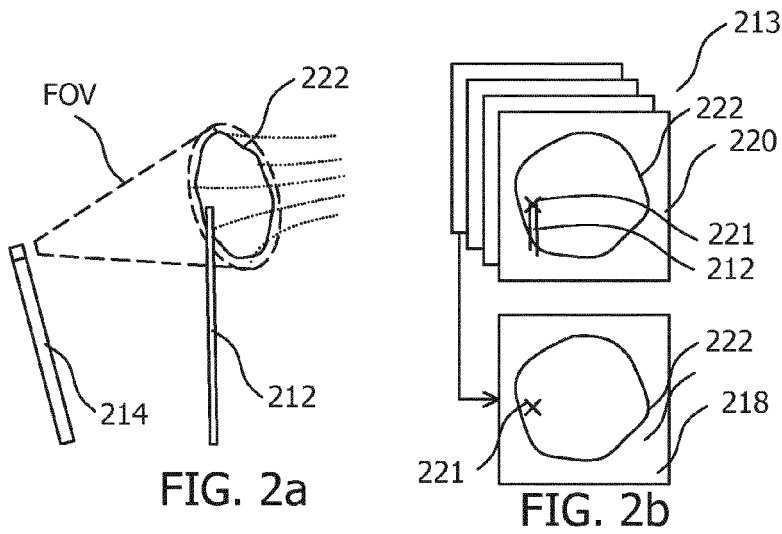


FIG. 2a

FIG. 2b

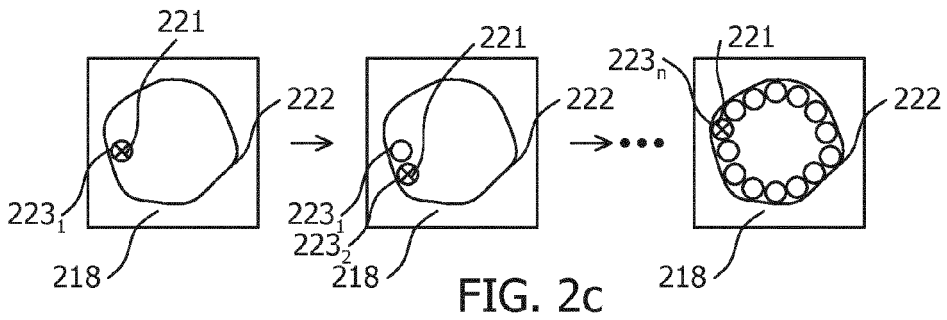


FIG. 2c

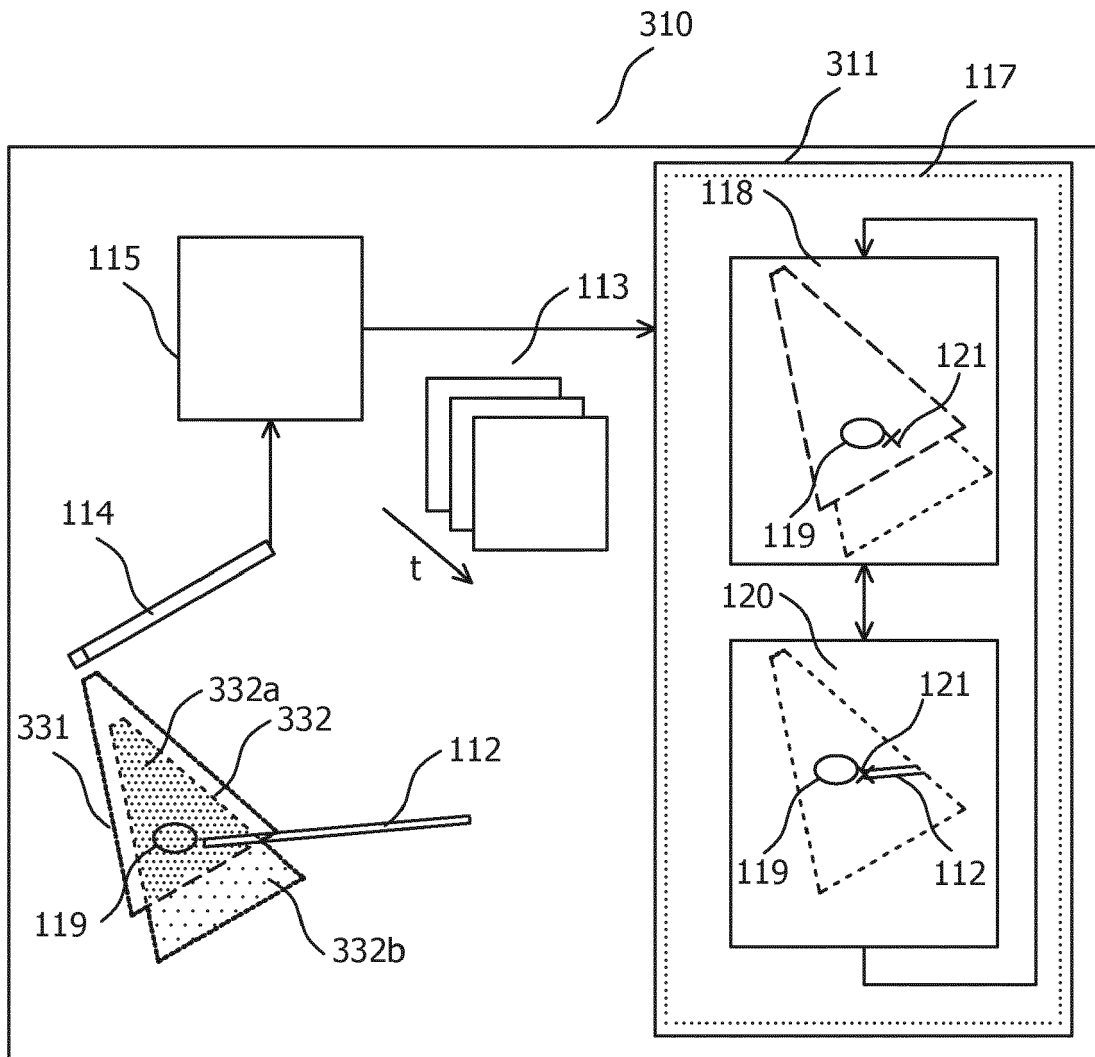


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 17 20 1547

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2016/059498 A1 (KONINKL PHILIPS NV [NL]; SUNNYBROOK HEALTH SCIENCES CT [CA]) 21 April 2016 (2016-04-21) * the whole document *	1-14	INV. A61B8/08 A61B8/12 A61B8/00 A61B18/00 A61N1/00
X	WO 2009/094646 A2 (UNIV NORTH CAROLINA [US]; FUCHS HENRY [US]; YANG HUA [US]; PECK TABITH) 30 July 2009 (2009-07-30) * page 2, line 13 - page 8, line 17; claims; figures *	1-14	
A	WO 2009/063423 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; KRUECKER JOCHEN [US]; XU SHENG [U]) 22 May 2009 (2009-05-22) * the whole document *	1-14	
A	WO 2011/070477 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; GOGIN NICOLAS P B [FR]; FLORENT R) 16 June 2011 (2011-06-16) * the whole document *	1-14	
A	US 2008/285824 A1 (WILDES DOUGLAS G [US] ET AL) 20 November 2008 (2008-11-20) * the whole document *	1-14	TECHNICAL FIELDS SEARCHED (IPC) A61B A61N
A	US 2012/029353 A1 (SLAYTON MICHAEL H [US] ET AL) 2 February 2012 (2012-02-02) * the whole document *	1-14	
A	CN 103 750 859 B (UNIV SOUTH CHINA TECH) 6 January 2016 (2016-01-06) * the whole document *	1-14	
A	WO 2016/178198 A1 (KONINKLIJKE PHILIPS NV [NL]) 10 November 2016 (2016-11-10) * the whole document *	1-14	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 April 2018	Examiner Mundakapadam, S
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 17 20 1547

5 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.

27-04-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016059498 A1	21-04-2016	CN 106999246 A	01-08-2017
		EP 3206617 A1	23-08-2017
		JP 2017532131 A	02-11-2017
		US 2017301088 A1	19-10-2017
		WO 2016059498 A1	21-04-2016

WO 2009094646 A2	30-07-2009	US 2011046483 A1	24-02-2011
		US 2016270862 A1	22-09-2016
		WO 2009094646 A2	30-07-2009

WO 2009063423 A1	22-05-2009	CN 101868737 A	20-10-2010
		EP 2212716 A1	04-08-2010
		JP 2011502687 A	27-01-2011
		RU 2010124373 A	27-12-2011
		US 2010268085 A1	21-10-2010
		WO 2009063423 A1	22-05-2009

WO 2011070477 A1	16-06-2011	CN 102651999 A	29-08-2012
		EP 2509507 A1	17-10-2012
		JP 5795769 B2	14-10-2015
		JP 2013513412 A	22-04-2013
		RU 2012128520 A	20-01-2014
		US 2012245458 A1	27-09-2012
		WO 2011070477 A1	16-06-2011

US 2008285824 A1	20-11-2008	NONE	

US 2012029353 A1	02-02-2012	EP 2600783 A2	12-06-2013
		EP 2600937 A2	12-06-2013
		KR 20130094814 A	26-08-2013
		KR 20130138727 A	19-12-2013
		US 2012029353 A1	02-02-2012
		US 2012143056 A1	07-06-2012
		US 2012165668 A1	28-06-2012
		US 2012165848 A1	28-06-2012
		US 2015360059 A1	17-12-2015
		US 2017080258 A1	23-03-2017
		WO 2012018385 A2	09-02-2012
		WO 2012018386 A2	09-02-2012
		WO 2012018390 A2	09-02-2012
WO 2012018391 A2	09-02-2012		

CN 103750859 B	06-01-2016	NONE	

WO 2016178198 A1	10-11-2016	EP 3291735 A1	14-03-2018
		WO 2016178198 A1	10-11-2016

EPO FORM P0459

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

55

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 20 1547

5 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.

27-04-2018

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date

15

20

25

30

35

40

45

50

EPO FORM P0459

55

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 8303505 B2 [0004]
- US 5655535 A [0018]
- US 8303505 B [0018]
- WO 2011138698 A1 [0029]
- US 8050523 B2 [0029]
- US 6233476 B1 [0029]

专利名称(译)	超声波跟踪和可视化		
公开(公告)号	EP3482690A1	公开(公告)日	2019-05-15
申请号	EP2017201547	申请日	2017-11-14
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	GIJSBERS GERARDUS HENRICUS MARIA KOLEN ALEXANDER FRANCISCUS BELT HARM JAN WILLEM HARKS GODEFRIDUS ANTONIUS		
发明人	GIJSBERS, GERARDUS HENRICUS MARIA KOLEN, ALEXANDER FRANCISCUS BELT, HARM JAN WILLEM HARKS, GODEFRIDUS ANTONIUS		
IPC分类号	A61B8/08 A61B8/12 A61B8/00 A61B18/00 A61N1/00		
CPC分类号	A61B8/0883 A61B8/0841 A61B8/0891 A61B8/12 A61B8/466 A61B8/483 A61B8/5207 A61B8/5246 A61B8/543 A61B18/1492 A61B2034/2063 A61B2090/364 A61B2090/378 A61N1/00		
代理机构(译)	德哈恩波尔ERIK		
外部链接	Espacenet		

摘要(译)

超声可视化系统111,311技术领域本发明涉及一种超声可视化系统111,311,用于基于实时超声图像流113跟踪介入设备112的位置。处理器117接收实时超声图像流113,提取包括以下内容的参考图像118。解剖特征119,从实时超声113的图像中提取当前图像120,其包括解剖特征119的一部分和介入设备112的当前位置121的一部分,匹配当前解剖特征的部分图像120具有参考图像118中的解剖特征以确定介入设备的当前位置与参考图像118中的解剖特征之间的空间关系,并且在参考图像118中指示介入的当前位置121设备112,基于所确定的空间关系。

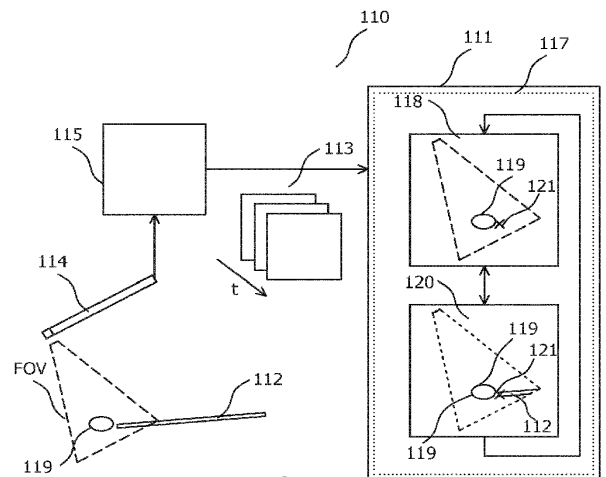


FIG. 1