



(11)

EP 2 509 507 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

04.04.2018 Bulletin 2018/14

(21) Application number: **10805324.0**

(22) Date of filing: **30.11.2010**

(51) Int Cl.:

A61B 6/12 (2006.01)

(86) International application number:

PCT/IB2010/055494

(87) International publication number:

WO 2011/070477 (16.06.2011 Gazette 2011/24)

(54) COMBINATION OF ULTRASOUND AND X-RAY SYSTEMS

KOMBINATION AUS ULTRASCHALL- UND RÖNTGENSTRAHLENSYSTEMEN

SYSTÈMES COMBINÉS À ULTRASONS ET RAYONS X

(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

(30) Priority: **09.12.2009 EP 09306203**

(43) Date of publication of application:

17.10.2012 Bulletin 2012/42

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to x-ray guided procedures. Especially, the invention relates to a method for processing an x-ray image. Furthermore, the invention relates to a system comprising an x-ray system as well as an ultrasound system, wherein the system is equipped with a computer program for performing the method.

BACKGROUND OF THE INVENTION

[0002] One of the challenges of image-guided medical and surgical procedures is to efficiently use the information provided by the many imaging techniques the patient may have been through before and during the intervention.

[0003] In cardiology, for example the physician often has access to real-time x-ray images acquired by a C-arm. These images have a very good spatial and temporal accuracy enable to follow precisely the progression of thin catheters and other interventional tools. However, soft-tissues are barely visible in these images, and furthermore, these images are projections which do not give a direct access to the volumetric geometry of the intervention scene. To gain access to this important information, a solution consists in using a second imaging modality which is both 3D and able to image soft-tissues.

[0004] One possible choice for this second imaging system is 3D ultrasound imaging. The advantage of this modality is that it can be used in real-time during the surgical procedure. In cardiological procedure, trans-esophageal probes can be navigated right next to the heart, producing real-time volumetric images with anatomical details that are hardly visible with standard transthoracic ultrasound.

[0005] Typical interventions currently involving this modality combination are ablation for atrial fibrillation, PFO closure (or other septal defect repair), and percutaneous valve repair (PVR). All those interventions are x-ray centric, but in all of them, the simultaneous involvement of ultrasound is either very helpful or completely mandatory to monitor the placement of the tool/endo-prosthesis with respect to the soft-tissue anatomy.

[0006] Although the ultrasound probe can deliver very useful images of the anatomy, an important drawback is the compromise that exists between the temporal acquisition frame rate and the extent of the field of view. It is therefore necessary to have a small field of view to acquire images at high frame rate.

[0007] But it is often difficult to select the optimum field of view, which size is constraint by the acquisition frame rate but which at the same time should include the area to be visualized.

[0008] Generally, a volume with a large field of view is first acquired and is used to select small sub-regions with-

in this first acquisition corresponding to the area of interest. In many interventions, the area of interest would include the interventional tools or some of them. So in practice, the acquisition volume could be targeted around the interventional tools. Unfortunately, the interventional tools cannot be easily visualized in ultrasound due to artifacts (acoustic reflections, shadows, etc.) and limited spatial resolution.

[0009] As a consequence, the actual steering of the probe beam so that it encompasses the interventional instrument is uneasy and requires specialized skill and attention. And this is made worse in interventions where both the anatomy and the device undergo strong movements (atrial fibrillation ablation, PFO closure, PVR).

[0010] Ultrasound through x-ray registration is usually performed using image-based registration techniques aiming at lining common structures visualized by both modalities. This approach has several drawbacks.

[0011] An important one is the difficulty to include the registration landmarks in the field of view which can be very limited in trans-esophageal echocardiograms (TEE). Moreover, natural landmarks such as the heart contours cannot be used because they are not visible in x-ray. The use of interventional tools as registration landmarks is challenging as they are not well defined in the ultrasound volume due to noise and artifacts.

[0012] Ultrasound to x-ray registration can also be achieved using tracking systems which give the position of the ultrasound probe with respect to the x-ray imaging system. Unfortunately, the ultrasound probe does not come with a standard tracking system that could be attached to the x-ray imaging system. Many systems have been designed to gap that void using physical trackers such as magnetic devices. These systems may be expensive and have several disadvantages: they can be disrupted by interference and require additional calibration steps which are prone to error.

[0013] Document US2009/0185657 discloses a method for geometric registration of a radiation device and an ultrasound emitter emitting fan-shaped signals within an object. The position of the emitter fan can be calculated from the position of the device. Thus, two imaging modalities can be registered with one another, enabling, for example, a merging of the images generated by the two modalities. Document US 2007/0276243 discloses a system for guiding a medical instrument in a patient body. An ultrasound probe placed on the patient body may be localized within the X-ray referential (reference coordinates). A bimodal representation of an ROI around a medical instrument is generated by combining the 2D X-ray image and a 3D ultrasound dataset of the ROI. The ultrasound probe localization is based on an active localizer e.g. an RF coil. Based on the RF signal, the position and orientation of the ultrasound probe in the X-ray referential can be determined.

[0014] The article "Computing intraoperative dosimetry" by French et al. discloses registering transrectal ultrasound (TRUS) and fluoroscopy images using a fluor-

oscopic image of the TRUS probe. From this image, corner points of the TRUS probe artefact are determined, which are subsequently used to determine certain offsets between the fluoroscopic image and the TRUS image.

SUMMARY OF THE INVENTION

[0015] The present invention is defined in the independent claims 1, 11 and 12. It is an object of the invention to provide a system and method for a combination of ultrasound and x-ray images.

[0016] It is a further object of the invention to provide a system and method for detecting the position and orientation of an ultrasound probe in an x-ray image.

[0017] It is a further object of the invention to provide a system and method for a better visualization of both an ultrasound and an x-ray image.

[0018] This is achieved by the subject matter of the respective independent claims. Further embodiments are described in the respective dependent claims.

[0019] In general, this is achieved by a method for a combination of ultrasound and x-ray images, comprising the steps of receiving an x-ray image, detecting an ultrasound probe in the x-ray image, and registering the probe including an estimation of a position and an orientation of the probe relative to a reference coordinate system.

[0020] It is noted that the reference coordinate system may be any pre-determined coordinate system. For example, the reference coordinate system may be within the plane of the x-ray image or may be defined relative to the C-arm of an x-ray system which may be used while performing the method.

[0021] According to another embodiment of the invention, the method comprises further a step of matching a digitally rendered projection of a 3D model of the probe with the detected probe in the x-ray image, wherein the estimation of the position and orientation of the probe is retrieved from the 3D model of the probe.

[0022] According to another aspect of that embodiment, the 3D model is retrieved from a CT acquisition or is a computer-aided design model.

[0023] Accordingly, a 2D x-ray image of an ultrasound probe may be registered with a 3D model of the probe which can be either a 3D acquisition of the probe or a computer-aided design (CAD). This registration is performed by matching a digitally rendered radiograph of the probe and the real x-ray projection of the probe. It is noted that a graphic processing unit (GPU) based algorithm may be used to generate digitally rendered radiograph in an efficient way.

[0024] The 2D-3D registration of the ultrasound probe gives the 3D pose of the probe with respect to the x-ray imaging system. There are several interesting applications such as merging the ultrasound image with x-ray image or ultrasound volume compounding in order to build an extended field of view.

[0025] The method may further comprise a step of visualizing an acquisition setting of the probe in the x-ray

image. By way of this, the operator can easily adjust the acquisition settings thanks to the information visualized in x-ray. It provides an interactive way to change the acquisition settings of the ultrasound acquisition system during an interventional procedure.

[0026] The acquisition setting may be the field of view of an ultrasound probe. The volume of the field of view of the ultrasound probe can be represented as a truncated pyramid in 3D. This pyramid may be indicated by the outlines of an area which can be visualized by an ultrasound system. Further, the pyramid may be defined by its centre together with parameters like the distance to the ultrasound sensor of the probe, a width, length, angle and/or a depth of the pyramid. The volume of the field of view may also be a truncated pyramid in one plane having a constant thickness perpendicular to said plane. With an appropriate calibration, the truncated pyramid can be projected and displayed in the x-ray image. As the operator changes the acquisition of the probe, the display of the acquisition volume in the x-ray image is automatically updated to provide a direct feedback to the operator.

[0027] Alternatively, one or more parameter like a main direction, an angle, a distance, a frame rate or a coordinate system, may be visualized in the x-ray image. The visualization of such parameters may be provided by for example points or lines or by numerals at an appropriate position in the x-ray image. A main direction may be a direction perpendicular to the surface of the ultrasound sensor or sensors at the ultrasound probe. A distance may be the distance of the ultrasound sensor to the center of the field of view or to a center of a reference coordinate system or to an interventional device also visible in the x-ray image or to any other predetermined point in the x-ray image.

[0028] This may allow for an interactive adjustment of the acquisition settings of the ultrasound acquisition system, through direct visualization in an x-ray acquisition system. By way of this, it may be easier for a clinician to adjust the orientation of an ultrasound probe relative to an interventional device like a catheter, wherein this catheter may be located within the truncated pyramid, i.e. within the field of view of the ultrasound probe.

[0029] According to another aspect of the invention, the method further comprises the step of detecting an interventional device in the x-ray image and manipulating the probe so that the interventional device is within the field of view of the probe. It is noted that this manipulation may be performed manually as well as automatically.

[0030] Accordingly, it may be possible to detect and track an interventional device in 2D x-ray image and to steer an ultrasound probe beam towards this device. The field of view of a probe can be automatically steered, and additionally the appearance of the intervention device in the fluoroscopy may be modified by for example blinking, flashing or coloring, when the device or at least a part of the device enters or is present in the field of view of the ultrasound probe. By way of this, the visualization will be enhanced and will dramatically help the steering of the

ultrasound probe beam in the interventional context.

[0031] Finally, the method may further comprise the step of overlaying an ultrasound image provided by the probe over the x-ray image. Furthermore, it may be possible to overlay a plurality of ultrasound images over only one x-ray image. This may provide for an extended field of view.

[0032] It is noted that the interventional device may be a flexible or stiff catheter or a biopsy device, a canula or trokar. The ultrasound probe may also be a trans-esophageal echocardiography ultrasound probe.

[0033] According to another aspect of the invention, a computer program is provided by means of which the above described method may be performed automatically, or at least predominantly automatically. Therefore, the computer program comprises sets of instructions for storing a x-ray image generated by an x-ray system, sets of instructions for detecting an ultrasound probe in that x-ray image, and sets of instructions for registering the probe and thus estimating the position and orientation of the ultrasound probe relative to a reference coordinate system. Furthermore, the computer program may comprise sets of instructions for receiving data representing a 3D model of the ultrasound probe.

[0034] Such a computer program may be implemented according to a further embodiment of the invention in a system including an x-ray system, an ultrasound system with a ultrasound probe, and a processing unit. Usually, such a system will include also a monitor for a visualization of the ultrasound as well as the x-ray images.

[0035] Such a computer program is preferably loaded into a work memory of a data processor. The data processor is thus equipped to carry out the method of the invention. Further, the invention relates to a computer readable medium, such as a CD-ROM, at which the computer program may be stored. However, the computer program may also be presented over a network like the World Wide Web and can be downloaded into the work memory of the data processor from such a network.

[0036] It will be understood that such a computer program may be either provided as software as well as may be implemented (at least partially) as hardware of a processing unit.

[0037] It has to be noted that the embodiments of the invention are described with reference to different subject matters. In particular, some embodiments are described with reference to method type claims whereas other embodiments are described with reference to apparatus type claims. However, a person skilled in the art will gather from the above and the following description that, unless or other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters is considered to be disclosed with this application.

[0038] The aspects defined above and further aspects, features and advantages of the present invention can also be derived from the examples of the embodiments

to be described hereinafter and are explained with reference to examples of embodiments also shown in the figures but to which the invention is not limited.

5 BRIEF DESCRIPTION OF THE DRAWINGS

[0039]

- Figure 1a shows an ultrasound probe retrieved from a CT acquisition.
- Figure 1b shows a non-aligned 3D model.
- Figure 1c shows an aligned 3D model.
- Figure 2 shows an x-ray image including an ultrasound probe.
- Figure 3 shows an x-ray image including an ultrasound probe as well as a schematic visualization of the field of view of said probe.
- Figure 4 is a diagram illustrating the system and method according to the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0040] Figure 1 shows, from left to right, an x-ray target image of an ultrasound probe, a non-aligned digitally rendered radiograph (DRR) of an ultrasound probe, as well as an aligned DRR. In figure 1c, the 3D model of figure 1b is orientated so that a projection thereof matches with the projection of the probe in the x-ray image of figure 1a.

[0041] The orientated 3D model of figure 1c is then combined with the x-ray image. Figure 2 shows such an overlay of an aligned DRR 110 on top of an x-ray image of chest 300 and heart 320, after intensity based registration, i.e. an estimation of the position and orientation of the probe. This gives the position/orientation of the probe with respect to the x-ray imaging system. If both systems are calibrated, the ultrasound image can be merged with the x-ray image. Also shown in figure 2 are interventional devices 200, for example catheters. A coordinate system in front of the ultrasound probe 110 indicates the estimated orientation of the ultrasound sensor elements relative to the image plane of the x-ray image.

[0042] An x-ray acquisition system is configured to produce real-time 2D x-ray images of an anatomical region during an interventional procedure. This modality does not allow clear visualization of complex soft-tissue anatomy such as the heart.

[0043] An ultrasound acquisition system with for example a trans-esophageal echocardiography (TEE) ultrasound probe, is configured to produce images of the anatomy. This ultrasound acquisition system is assumed to lie at least partially in the field of view of the x-ray acquisition system with sufficient information that it is enough to recover the coordinate system of the images produced by this system. It is the case for example when the whole detector of the ultrasound acquisition system is present in the x-ray image and/or when its position can be estimated from other structures present in the x-ray image.

[0044] Subsequently, a 3D model of the ultrasound probe may be used to automatically compute the pose of the probe. This may be done by matching the x-ray image of the ultrasound probe with a digitally rendered radiograph generated by transparent projection of the 3D model (cf. figures 1 and 2). An optimization algorithm allows retrieving the 6 pose-parameters of the probe which gives the 3D position of the probe and its 3D orientation with respect to for example the C-arm system defining a reference coordinate system.

[0045] An offline calibration of the probe gives the relationship between the ultrasound image and the 3D model. In combination with the previous step, it is then possible to have the relationship between the ultrasound image and the x-ray imaging system, and therefore with the x-ray image if the x-ray imaging system is also calibrated.

[0046] Fusion between x-ray image and ultrasound image is then straight forward. Another interesting application is the use of the x-ray imaging system as a reference coordinate system to compound different ultrasound acquisition and build an extended field of view which is of great interest for TEE acquisitions where the field of view is often very limited.

[0047] As exemplarily shown in figure 3, the volume of acquisition 130 of the ultrasound probe 110 may be represented as a truncated pyramid in 3D, assuming that the position and orientation of the ultrasound probe 110 with respect to the x-ray image is known. As can be seen in figure 3, an interventional device 200 with its interventional end portion may be located such that the field of view 130 encompasses that interventional end portion of the device 200. Further shown in figure 3 is an angle 140 determining the angle of beam of the field of view of the ultrasound probe. Here, the angle of beam is 42,3 degree.

[0048] In figure 4 is a flow chart showing the steps of a method for a combination of ultrasound and x-ray images according to the invention. The patient is simultaneously imaged by an ultrasound system 100 and an x-ray system 400. In a preferred embodiment, a considered ultrasound probe of the ultrasound system 100 is capable of generating synthetically steered beams, preferably in 3D.

[0049] It will be understood that the steps described with respect to the method are major steps, wherein these steps might be differentiated or divided into several sub-steps. Furthermore, there might be also sub-steps between these major steps. Therefore, a sub-step is only mentioned if that step is important for the understanding of the principles of the method according to the invention.

[0050] In step S1, the ultrasound system 100 and the x-ray imaging system 400 are first mutually registered. This can typically be achieved by imaging the probe of the ultrasound system 100 by the x-ray system 400, and based on the settings 150 and data 160 of the ultrasound system 100 and on the settings 410 of the x-ray system 100, plus on the possible use of a probe 3D model 500 or markers, in determining the position of the probe in

the x-ray referential. From this information, and based on the relevant calibration information, one can use the parameters of the probe field of view in the x-ray referential, as described above. Data S1c will be exchanged for visualization of the resulting image.

[0051] In step S2, at the same time, the intervention device (for instant the tip of a catheter), is detected and tracked in the x-ray images. This step relies on data 420 of the x-ray system 400 and on usual object detection means that rely on the spatial signature of the device and possibly on its motion characteristics (for instance, the device is animated by a cardiac motion plus a steering motion, seen in projection).

[0052] In step S3, it is advantageous to improve the 2D location provided by device tracking in the x-ray images and to try to get a depth estimation of the considered device. Several approaches are possible to reach the goal, among which the exploitation of the devices observed width, the use of other x-ray views under different angulation for instance in bi-plane context or the use of wiggling motions. For example, the width of the ultrasound probe may be estimated, wherein subsequently possible locations of the ultrasound probe are discriminated on the basis of the estimated size and of a segmentation of the imaged object.

[0053] In step S4, the device-improved location S3a can then be compared to the found ultrasound field of view S1b, and several commands can be issued accordingly. For instance, a device flashing/blinking command can be issued to the imaging processing channel of the x-ray data stream, or a probe steering command S4a can be sent to the relevant module.

[0054] On the other hand, the data S4b of step S4 together with the information S2a of step S2 will result in step S5, i.e. the visualization of the device in the x-ray image which is adapted based on events such as the entering (blinking/flashing) or the presence (coloring) of the device in the ultrasound field of view. This provides the ultrasound user with an easy way of controlling the steering of the probe based on the high resolution x-ray images. Of course, this steering is also made easier by the visualization of the ultrasound cone as shown in figure 3. The result of step S5 is an enhanced 2D view S5a facilitating the steering of the ultrasound probe.

[0055] In step S6, alternatively or complementarily, a command S6a can be issued to the beam-steering module of the ultrasound system 100, as to which field of view one should generate in order to nicely visualize the device at the center of the ultrasound cone (volume or image). The probe steering module, based on the ultrasound/x-ray registration information will determine and apply the relevant set parameters enabling this device-driven steering.

[0056] When the invention has been illustrated and described in detail in the drawings and afore-going description, such illustrations and descriptions are considered illustrative or exemplary and not restrictive, the invention is not limited to the disclosed embodiments.

[0057] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from the pendent claims. In the claims, the word comprising does not exclude other elements or steps, and the indefinite article a or an does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere effect that certain measures are recited and mutually different, dependent claims does not indicate that a combination of these measured cannot be used to advantage. A computer program may be stored/distributed on a suitable medium such as an optical storage medium or a solid-state medium supplied together with or as a part of another hardware, but may also be distributed in other forms, such as via the internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope.

LIST OF REFERENCE SIGNS:

[0058]

100 ultrasound system
 110 ultrasound probe
 120 ultrasound probe coordinate system
 130 field of view
 140 angle of field of view
 150 ultrasound probe settings
 160 ultrasound data stream
 200 interventional device
 300 chest
 320 heart
 400 x-ray system
 410 x-ray acquisition parameters
 420 x-ray data stream
 500 3D probe model
 S1a registration parameter
 S1b ultrasound field of view in x-ray referential
 S1c data exchange
 S2a device localization
 S3a improved device localization
 S4a probe steering commands
 S4b in field of view signal
 S5a enhanced 2D view of manual steering
 S6a probe parameter

Claims

1. A method for processing an x-ray image, the method comprising the steps of:

receiving a 2D x-ray image,
 detecting (S2) an ultrasound probe in the 2D x-ray image,
 registering (S1) the detected ultrasound probe with a 3D model (500) of the probe by matching

a digitally rendered radiograph of the 3D model with a projection of the probe in the 2D x-ray image, and
 estimating a position and an orientation of the ultrasound probe relative to a reference coordinate system based on the registration.

2. The method of claim 1, wherein the 3D model (500) is retrieved from a CT acquisition or is a computer-aided design model.

3. The method of claim 1, further comprising the step of detecting an interventional device (200) in the x-ray image.

4. The method of claim 3, further comprising the step of generating a probe steering command (S4a) for steering the ultrasound probe so that the interventional device is within the field of view of the ultrasound probe.

5. The method of claim 4, wherein the ultrasound probe is automatically steered by a beam-steering module of an ultrasound system.

6. The method of claim 3, further comprising adapting (S5) a visualization of the detected interventional device in the x-ray image, if the interventional device is within the field of view of the ultrasound probe.

7. The method of any one of claims 1 to 6, further comprising the step of tracking the ultrasound probe in a series of x-ray images.

8. The method of claim 1, further comprising the step of overlaying an ultrasound image provided by the ultrasound probe over the x-ray image.

9. The method of any preceding claim, further comprising the step of visualizing, in the x-ray image, an acquisition setting of the ultrasound probe.

10. The method of claim 9, wherein the acquisition setting is a field of view (130) of the ultrasound probe, and the visualization includes an outline of said field of view represented as a truncated pyramid in 3D, in accordance with the estimated position and orientation of the ultrasound probe.

11. A computer program, comprising sets of instructions for performing the method of any preceding claim..

12. A system for a combination of ultrasound and x-ray images, the system comprising
 an x-ray system (400),
 an ultrasound system (100) including an ultrasound probe (110), a monitor and
 a processing unit configured to carry out the steps

of a method according to any one of claims 1-10.

13. The system of claim 12 insofar as dependent on claim 8, wherein the monitor is configured to display the overlaid ultrasound and x-ray images.

Patentansprüche

1. Verfahren zum Verarbeiten eines Röntgenbildes, wobei das Verfahren folgende Schritte umfasst:

Empfangen eines 2D-Röntgenbildes,
Detektieren (S2) einer Ultraschallsonde in dem 2D-Röntgenbild,
Registrieren (S1) der detektierten Ultraschallsonde mit einem 3D-Modell (500) der Sonde durch Abgleichen einer digital gerenderten Röntgenaufnahme des 3D-Modells mit einer Projektion der Sonde in das 2D-Röntgenbild und Schätzen einer Position und einer Ausrichtung der Ultraschallsonde in Bezug auf ein Referenzkoordinatensystem basierend auf der Registrierung.

2. Verfahren nach Anspruch 1, wobei das 3D-Modell (500) aus einer CT-Erfassung abgerufen wird oder ein computergestütztes Designmodell ist.

3. Verfahren nach Anspruch 1, ferner umfassend den Schritt des Detektierens einer Eingriffsvorrichtung (200) in dem Röntgenbild.

4. Verfahren nach Anspruch 3, ferner umfassend den Schritt des Erzeugens eines Sondenlenkbefehls (S4a) zum Lenken der Ultraschallsonde, so dass die Eingriffsvorrichtung innerhalb des Sichtfeldes der Ultraschallsonde ist.

5. Verfahren nach Anspruch 4, wobei die Ultraschallsonde automatisch durch ein Strahlenkmodul eines Ultraschallsystems gelenkt wird.

6. Verfahren nach Anspruch 3, ferner umfassend das Anpassen (S5) einer Visualisierung der detektierten Eingriffsvorrichtung in dem Röntgenbild, wenn sich die Eingriffsvorrichtung innerhalb des Sichtfeldes der Ultraschallsonde befindet.

7. Verfahren nach einem der Ansprüche 1 bis 6, ferner umfassend den Schritt des Nachverfolgens der Ultraschallsonde in einer Reihe von Röntgenbildern.

8. Verfahren nach Anspruch 1, ferner umfassend den Schritt des Überlagerns eines Ultraschallbildes, das durch die Ultraschallsonde über dem Röntgenbild bereitgestellt wird.

9. Verfahren nach einem der vorhergehenden Ansprüche, ferner umfassend den Schritt des Visualisierens einer Erfassungseinstellung der Ultraschallsonde in dem Röntgenbild.

10. Verfahren nach Anspruch 9, wobei die Erfassungseinstellung ein Sichtfeld (130) der Ultraschallsonde ist und die Visualisierung einen Umriss des Sichtfeldes einschließt, der als eine Pyramide in 3D gemäß der geschätzten Position und Ausrichtung der Ultraschallsonde dargestellt ist.

11. Computerprogramm, umfassend Sätze von Anweisungen zum Durchführen des Verfahrens nach einem der vorhergehenden Ansprüche.

12. System für eine Kombination von Ultraschall- und Röntgenbildern, wobei das System ein Röntgensystem (400), ein Ultraschallsystem (100) einschließlich einer Ultraschallsonde (110), einen Monitor und eine Verarbeitungseinheit umfasst, die zum Ausführen der Schritte eines Verfahrens nach einem der Ansprüche 1 bis 10 konfiguriert sind.

13. System nach Anspruch 12, soweit abhängig von Anspruch 8, wobei der Monitor zum Anzeigen der überlagerten Ultraschall- und Röntgenbilder konfiguriert ist.

Revendications

1. Procédé pour traiter une image radiologique, le procédé comprenant les étapes suivantes :

la réception d'une image radiologique en 2D,
la détection (S2) d'une sonde ultrasonore dans l'image radiologique en 2D,
l'enregistrement (S1) de la sonde ultrasonore détectée avec un modèle 3D (500) de la sonde en faisant correspondre un radiogramme restitué numériquement du modèle 3D avec une projection de la sonde dans l'image radiologique en 2D, et
l'estimation d'une position et d'une orientation de la sonde ultrasonore par rapport à un système de coordonnées de référence sur la base de l'enregistrement.

2. Procédé selon la revendication 1, dans lequel le modèle 3D (500) est récupéré à partir d'une acquisition de tomodensitométrie ou est un modèle de conception assistée par ordinateur.

3. Procédé selon la revendication 1, comprenant en outre l'étape de détection d'un dispositif d'intervention (200) dans l'image radiologique.

4. Procédé selon la revendication 3, comprenant en outre l'étape de génération d'une commande d'orientation de sonde (S4a) pour orienter la sonde ultrasonore de sorte que le dispositif d'intervention soit compris dans le champ de vision de la sonde ultrasonore. 5
5. Procédé selon la revendication 4, dans lequel la sonde ultrasonore est orientée automatiquement par un module d'orientation de faisceaux d'un système ultrasonore. 10
6. Procédé selon la revendication 3, comprenant en outre l'adaptation (S5) d'une visualisation du dispositif d'intervention détecté dans l'image radiologique, si le dispositif d'intervention est compris dans le champ de vision de la sonde ultrasonore. 15
7. Procédé selon l'une quelconque des revendications 1 à 6, comprenant en outre l'étape de suivi de la sonde ultrasonore dans une série d'images radiologiques. 20
8. Procédé selon la revendication 1, comprenant en outre l'étape de superposition d'une image ultrasonore fournie par la sonde ultrasonore sur l'image radiologique. 25
9. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre l'étape de visualisation, dans l'image radiologique, d'un réglage d'acquisition de la sonde ultrasonore. 30
10. Procédé selon la revendication 9, dans lequel le réglage d'acquisition est un champ de vision (130) de la sonde ultrasonore, et la visualisation inclut un contour dudit champ de vision représenté sous forme d'une pyramide tronquée en 3D, en fonction de la position et de l'orientation estimées de la sonde ultrasonore. 35
40
11. Programme informatique, comprenant des ensembles d'instructions pour mettre en oeuvre le procédé selon l'une quelconque des revendications précédentes. 45
12. Système pour une combinaison d'images ultrasonores et radiologiques, le système comprenant un système radiologique (400), un système ultrasonore (100) incluant une sonde ultrasonore (110), un dispositif de surveillance et une unité de traitement configurée pour réaliser les étapes du procédé selon l'une quelconque des revendications 1 à 10. 50
55
13. Système selon la revendication 12, dans la mesure où il dépend de la revendication 8, dans lequel

le dispositif de surveillance est configuré pour afficher les images ultrasonores et radiologiques superposées.

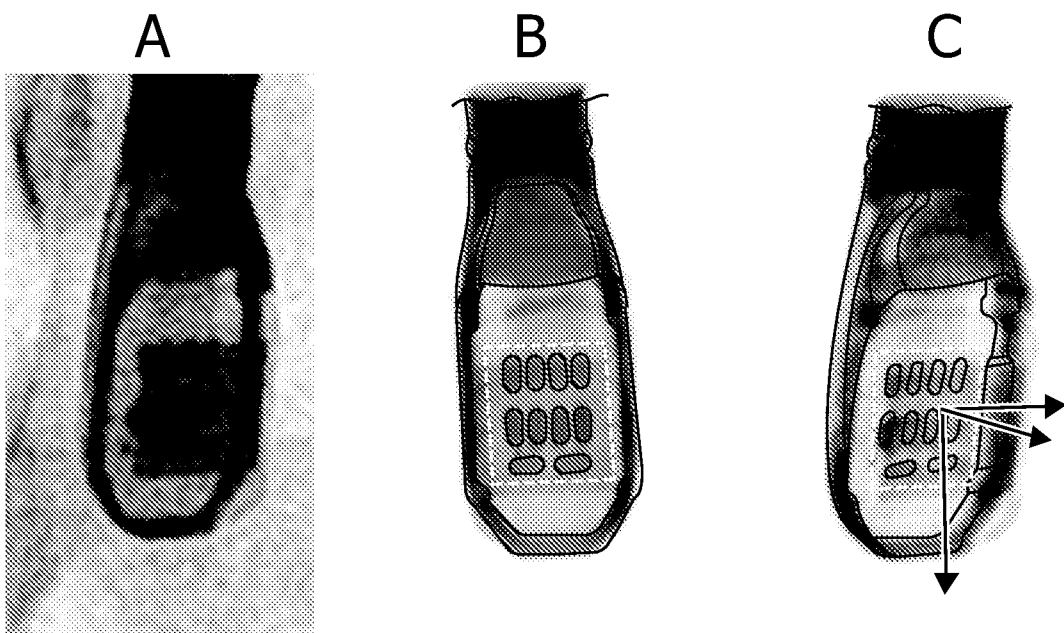


FIG. 1

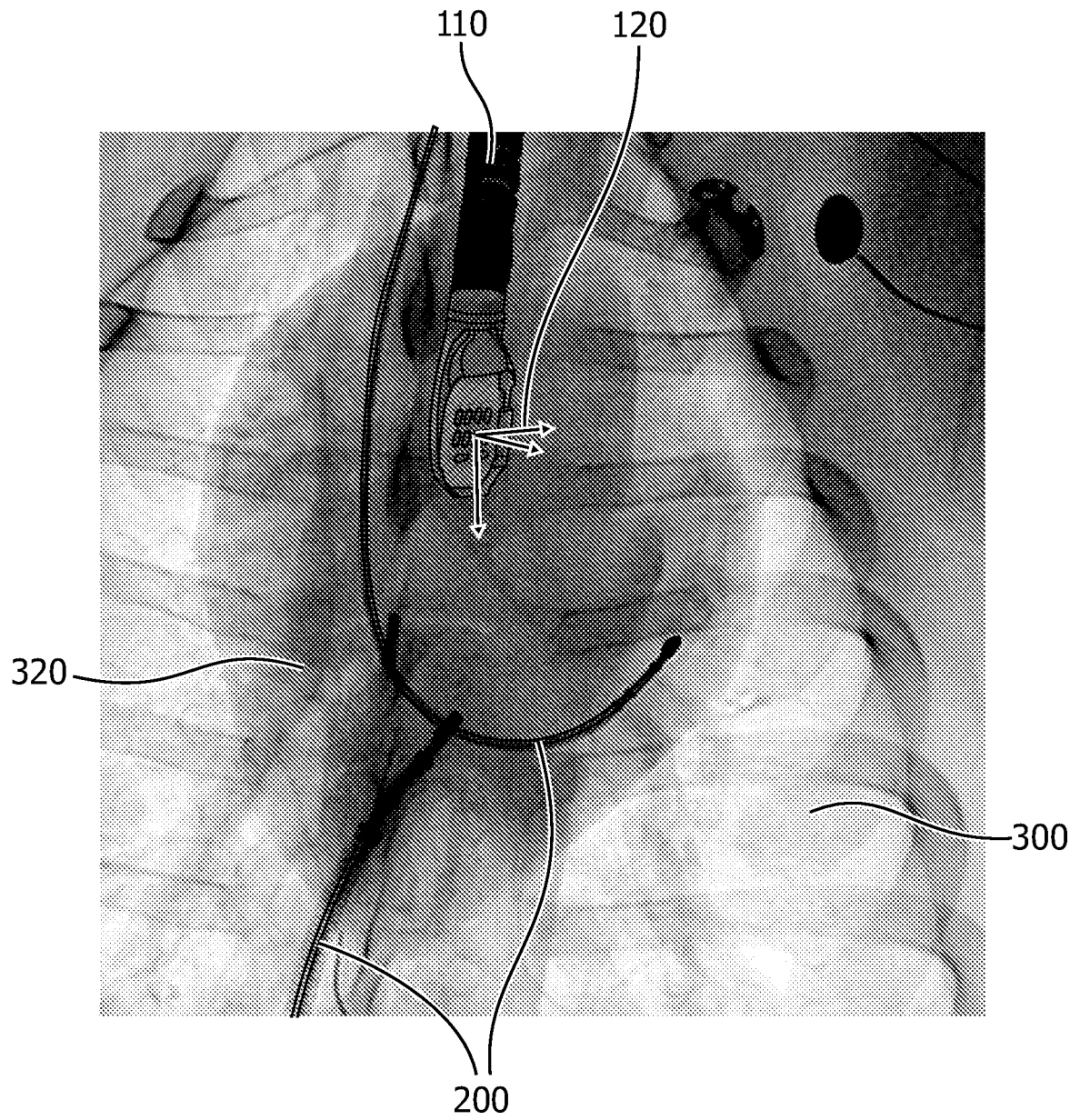


FIG. 2

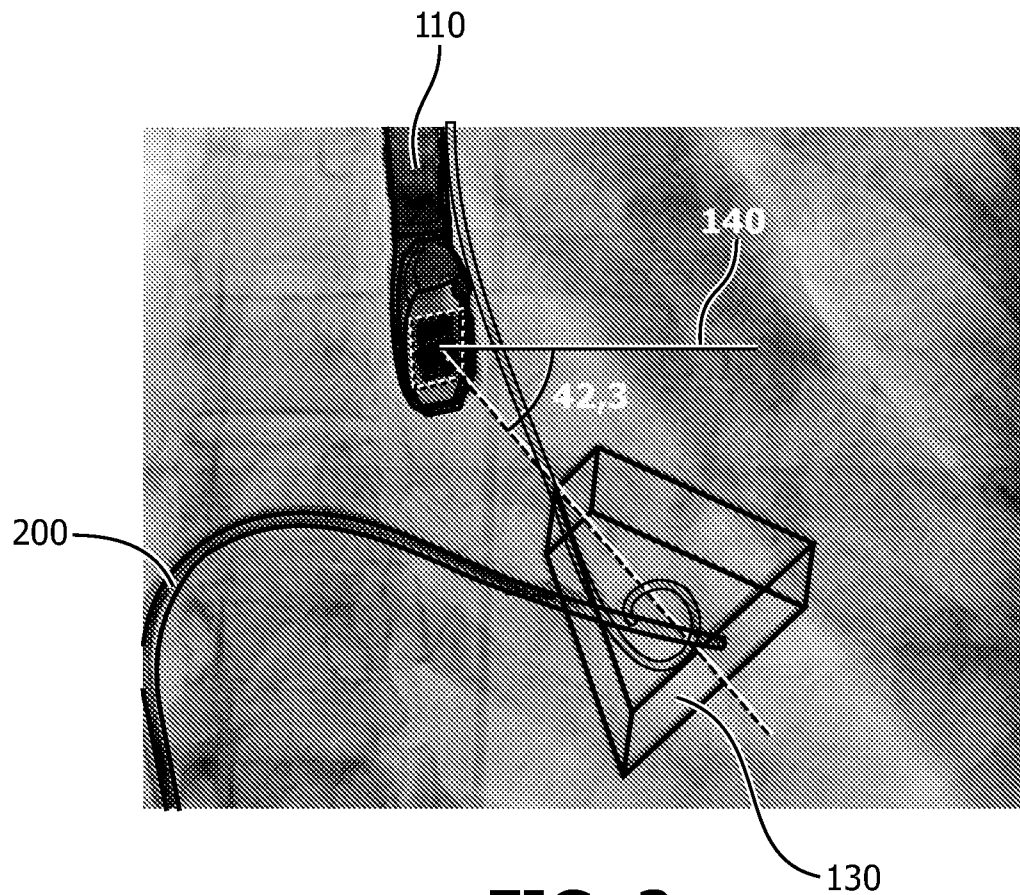


FIG. 3

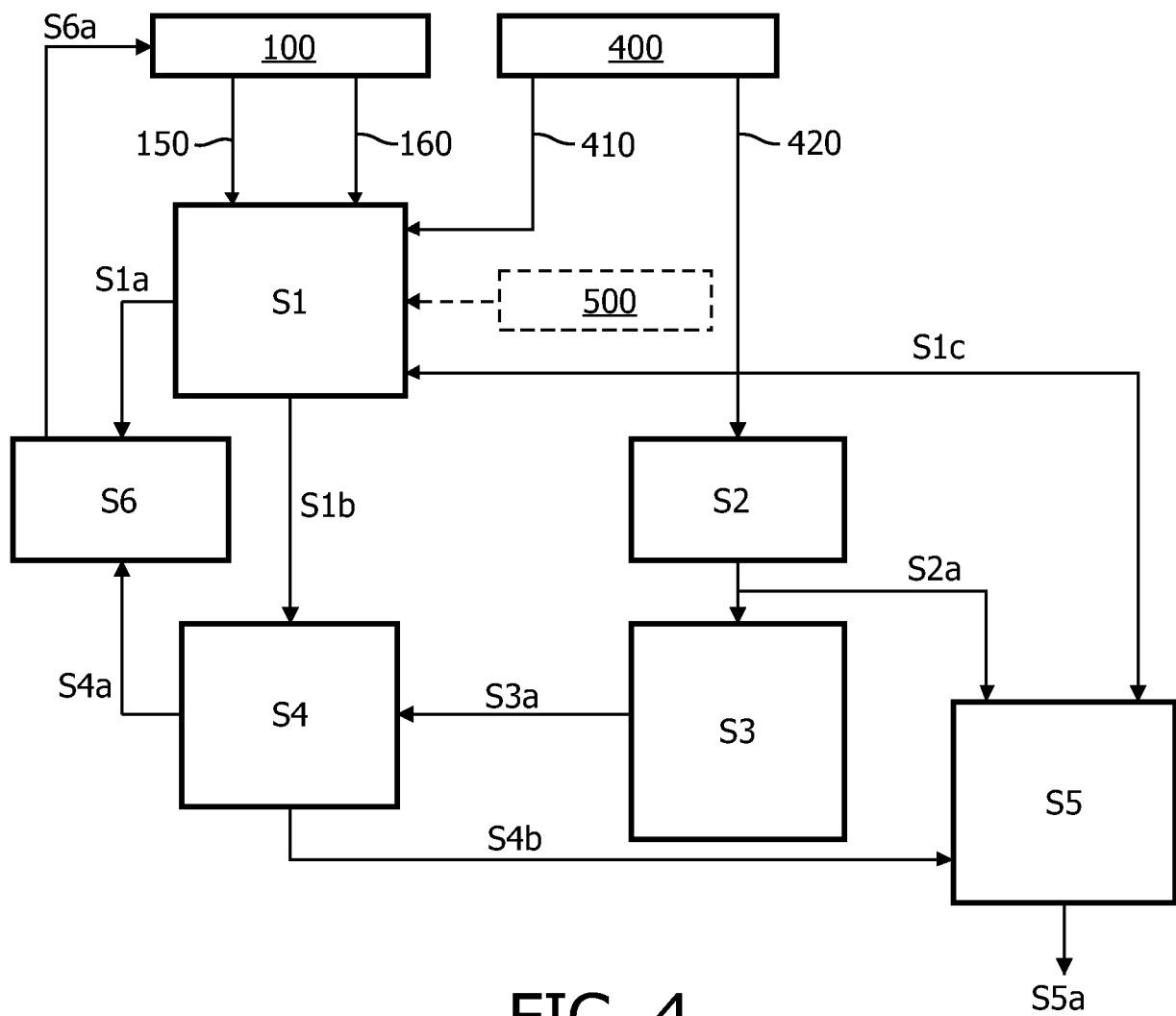


FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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专利名称(译)	超声和X射线系统的结合		
公开(公告)号	EP2509507A1	公开(公告)日	2012-10-17
申请号	EP2010805324	申请日	2010-11-30
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
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IPC分类号	A61B8/00 A61B6/00		
CPC分类号	A61B8/00 A61B6/00 A61B6/12 A61B6/503 A61B6/5247 A61B8/0883 A61B8/4245 A61B8/4416		
优先权	2009306203 2009-12-09 EP		
其他公开文献	EP2509507B1		
外部链接	Espacenet		

摘要(译)

本发明提出检测和跟踪2D荧光透视图像中的介入装置并将超声探测束导向该装置。因此，提出了一种方法和相应的系统，通过该方法和相应的系统将超声探头配准在荧光检查图像中，其中配准包括估计探头相对于荧光透视的位置和取向。