(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau

(43) International Publication Date
27 October 2016 (27.10.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/169759 A1

[Continued on next page]

(54) Title: MEDICAL IMAGING APPARATUS
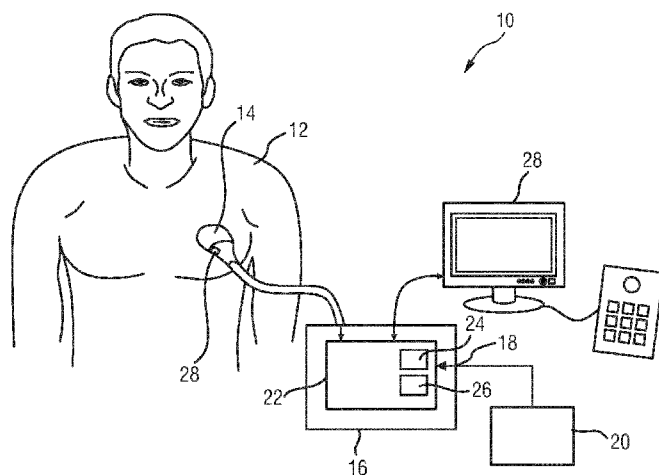
FIG.1

(57) Abstract: The present invention relates to a med-
ical imaging apparatus (10).The apparatus comprises
an ultrasound acquisition unit including an ultrasound
probe (14) for acquiring ultrasound image data of a pa-
tient (12). An image data interface (18) is provided for
receiving 3D medical image data of the patient and a
position determining unit (28) for determining a posi-
tion of the ultrasound probe. A calibration unit (24)
determines a transfer function between the ultrasound
image data and the 3D medical image data at a plural-
ity of positions (C) of the ultrasound probe and
provides a corresponding plurality of calibrated trans-
fer functions and calibration positions. A computation
unit (26) synchronizes the ultrasound image data and
the 3D medical image data on the basis of a position of
the ultrasound probe and the plurality of calibrated
transfer functions, said computation unit is further ad-
apted to weight the calibrated transfer functions on the
basis of a position of the ultrasound probe.

WO 2016/169759 A1

— with information concerning request for restoration of the right of priority in respect of one or more priority claims; the decision of the receiving Office regarding the request for restoration is pending and will be published separately once available (Rules 26bis.3 and 48.2(j))

Medical imaging apparatus

FIELD OF THE INVENTION

The present invention relates to a medical imaging apparatus for evaluating medical image data. The present invention further relates to a medical imaging method.

5   BACKGROUND OF THE INVENTION

In the field of medical imaging systems, it is generally known to combine different images of a patient acquired by different medical analysis systems in order to improve the diagnostic possibilities. In particular, ultrasound systems are known which combine ultrasound images and preoperative image data of a patient derived from different

10   analytic systems like MRT or CT. To enable a fusion of live ultrasound images of a patient with the preoperative volume data of the same patient, a position tracking system is usually utilized to spatially align the different image data.

The position tracking systems usually rely on a position calibration, e.g. based on artificial markers or feature alignment of anatomical features which can be identified in

15   the preoperative and in the ultrasound data and which can be correlated to each other so that the alignment of the data can be determined.

The alignment of the ultrasound image data and the medical image data can be based on ultrasound probe calibration information to provide a spatial alignment of the image data as e.g. known from US 2010/0286517 A1.

20   The accuracy of the spatial synchronization of the ultrasound data and the medical image data is dependent on the distance of the ultrasound probe and the calibration position so that a misalignment of the synchronization increases with a distance from the calibration position. Usually if a misalignment occurs, a recalibration of the image data and the tracking system is performed, however, a misalignment at the previously calibrated

25   position will occur again.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an improved medical imaging apparatus and a corresponding improved medical imaging method for synchronizing different medical image data with an improved accuracy.

According to one aspect of the present invention, a medical imaging apparatus is provided, comprising:

- an ultrasound acquisition unit including an ultrasound probe for acquiring ultrasound image data of a patient,

- an image data interface for receiving 3D medical image data of the patient,

- a position determining unit for determining a position of the ultrasound probe,

- a calibration unit adapted to determine a transfer function between the ultrasound image data and the 3D medical image data at a plurality of positions of the ultrasound probe and adapted to provide a corresponding plurality of calibrated transfer functions and calibration positions, and

- a computation unit adapted to synchronize the ultrasound image data and the 3D medical image data on the basis of a position of the ultrasound probe and the plurality of calibrated transfer functions.

According to another aspect of the present invention, a medical imaging method for combining different medical image data is provided comprising the steps of:

- acquiring ultrasound data of a patient by means of an ultrasound probe,

- receiving 3D medical image data of the patient,

- determining a position of the ultrasound probe by means of a position determining unit,

- determining a transfer function between the ultrasound image data and the medical image data at a plurality of positions of the ultrasound probe and providing a corresponding plurality of calibrated transfer functions and calibration positions, and

- synchronizing the ultrasound image data and the 3D medical image data on the basis of a position of the ultrasound probe and the plurality of transfer functions.

Preferred embodiments of the invention are defined in the dependent claims. It shall be understood that the claimed method has similar and/or identical preferred embodiments as the claimed device and as defined in the dependent claims.

The present invention is based on the idea to determine a plurality of transfer functions linking the ultrasound image data and the 3D medical image data with each other for a plurality of positions of the ultrasound probe in order to provide corresponding

calibration positions of the ultrasound probe on the basis of which the ultrasound image data and the 3D medical image data is synchronized. Since different calibration positions are determined by means of the calibration unit, the distance of the ultrasound probe to one of the calibration positions can be considered so that the accuracy of the spatial synchronization of the ultrasound image data and the 3D medical image data can be improved. Since the different calibration positions and the determined plurality of calibrated transfer functions are simultaneously or at the same time utilized for the synchronization of the image data, the spatial alignment of the different image data can be improved for a large area of the patient's body.

Consequently, the accuracy of the spatial synchronization of the ultrasound image data and the 3D medical image data can be improved.

In accordance to the present invention, the computation unit is adapted to weight the calibrated transfer functions on the basis of a position of the ultrasound probe. This is a possibility to utilize the different calibrated transfer functions depending on the position of the ultrasound probe, so that the optimal calibrated transfer function can be considered for synchronizing the image data.

In a preferred embodiment, the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance between the ultrasound probe and a plurality of the calibration positions. This is a possibility to improve the synchronization, since the accuracy of the synchronization depends on the distance to the calibration positions.

In a preferred embodiment, the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance between a predefined position at a tip of the ultrasound probe and a plurality of the calibration positions. This is a possibility to determine the calibrated transfer functions on the basis of a defined reference position at the ultrasound probe, so that a precise definition of the transfer function can be achieved with low technical effort.

In a further preferred embodiment, the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance between a predefined position within the ultrasound image data and a plurality of the calibration positions. This is a possibility to determine the calibrated transfer functions on the basis of a defined reference position within the ultrasound image data, so that a precise definition of the transfer function can be achieved with low technical effort.

In a further preferred embodiment, the predefined position within the ultrasound image data to a plurality of the calibration positions is a center of the ultrasound

image data. The center of the ultrasound image data corresponds to a center of the field of view of the ultrasound probe or an axis of symmetry of the ultrasound cone. This is a possibility to define a reference point of the ultrasound image data so that the calibrated transfer functions can be determined precisely with low technical effort.

In a preferred embodiment, the computation unit is adapted to weight the calibrated transfer functions by means of relative weight factors. The relative weight factors have preferably a value between 1 and 0. In other words, the relative weight factors are normalized. This is a possibility to achieve a weighting of the calibrated transfer functions, wherein each transfer function can be considered on the basis of the respective relevance.

In a preferred embodiment, the computation unit is adapted to weight the calibrated transfer functions on the basis of absolute weight factors. The absolute weight factors have the value of either 1 or 0. This is a possibility to further reduce the computation effort of the synchronization of the image data, since only those calibration transfer functions having the highest relevance are considered. In particular, the transfer function having the closest calibration position to the current position is considered as the only calibrated transfer function and the other calibrated transfer functions are not considered.

In a preferred embodiment, the calibration unit is adapted to determine a 3D rigid transformation for each calibration position. The transfer function is determined on the basis of the rigid transformation or a 3D fixed transformation between the different image data for each calibration position. This is a possibility to determine the spatial synchronization precisely with low technical effort, since a fixed transformation is provided for each calibration position.

In a preferred embodiment, the computation unit is adapted to determine a general transfer function for a current position of the ultrasound probe on the basis of the calibrated transfer functions weighted by means of weight factors. This is a possibility to precisely determine the synchronization of the ultrasound image data and the medical image data, since a single general transfer function is determined on the basis of different calibration information.

In a preferred embodiment, the medical imaging apparatus further comprises an image interface for providing fused image data on the basis of the synchronized ultrasound image data and the 3D medical image data to a display unit. This is a possibility to display the combined image data.

As mentioned above, the medical imaging apparatus for combining different medical image data and the corresponding method can improve the accuracy of the spatial

synchronization of the ultrasound and medical image data since the synchronization is based upon a plurality of calibrated transfer functions, which correspond to the calibration at different positions of the ultrasound probe. This is a possibility to utilize at least one transfer function which provides the best calibration and synchronization so that the spatial alignment of the image data can be improved. The definition of the different calibrated transfer functions corresponding to different calibration positions can further be utilized for a weighting based on the position of the ultrasound probe and/or a distance to the calibration positions so that a resulting overall or general transfer function can be determined on the basis of different calibration positions and the respective position of the ultrasound probe. Hence, the accuracy and the technical effort for fusing the ultrasound and medical image data can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter. In the following drawings

Fig. 1 shows a schematic representation of a medical imaging apparatus in use to scan a volume of a patient's body;

Fig. 2 shows a schematic diagram illustrating the calibration at different positions of the ultrasound probe and a current position of the ultrasound probe; and

Fig. 3 shows an ultrasound image including a central reference positions for determining the calibration position.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows a schematic illustration of a medical imaging apparatus generally denoted by 10. The medical imaging apparatus 10 is applied to inspect a volume of an anatomical site, in particular an anatomical site of a patient 12. The medical imaging apparatus 10 comprises an ultrasound probe 14 having at least one transducer array including a multitude of transducer elements for transmitting and receiving ultrasound waves. The transducer elements are preferably arranged in a 2D array, in particular for providing multidimensional image data.

The medical imaging apparatus 10 comprises in general an image processing apparatus 16 connected to the ultrasound probe 14 for evaluating the ultrasound data received from the ultrasound probe and for combining or correlating the ultrasound images with preoperative images of the patient 12. The image processing apparatus 16 comprises an

image interface 18 for receiving the preoperative 3D medical image data from a data base 20

or an external analysis and imaging apparatus 20. The preoperative image data is preferably

computer tomography image data (CT), magnetic resonance tomography image data (MRT),

X-ray image data or preoperative 3D ultrasound image data. The image processing apparatus

5   16 comprises an image processing unit 22 connected to the ultrasound probe 14 and to the

image interface 18 for evaluating the ultrasound data and for providing ultrasound image data

from the volume or object of the patient which is analyzed by the ultrasound probe 14 and for

combining the preoperative 3D medical image data received from the image interface 18 with

the ultrasound data received from the ultrasound probe 14.

10   The medical imaging apparatus 10 further comprises a position determining

unit 28 attached to the ultrasound probe 14 for determining a position of the ultrasound probe

14. The position determining unit determines the absolute position of the ultrasound probe,

e.g. by means of electromagnetic tracking in order to determine a position and/or a movement

of the ultrasound probe 14.

15   An image processing unit 22 comprises a calibration unit 24 for calibrating

different positions of the ultrasound probe with respect to the 3D medical image data and to

provide corresponding calibration positions of the ultrasound probe 14. The calibration unit

24 determines at the different calibration positions transfer functions between the ultrasound

image data determined by the ultrasound probe 14 at the calibration position and the

20   corresponding 3D medical image data. The transfer function between the ultrasound image

data and the 3D medical image data is a mathematic transformation between corresponding

spatial positions in the ultrasound image data and the 3D medical image data such as voxels

so that each spatial or three-dimensional position in the ultrasound image data and the 3D

medical image data can be correlated with each other.

25   The calibration unit determines a transfer function at each different calibration

position so that the calibration unit 22 provides a plurality of transfer functions for calibrating

the medical imaging apparatus 10. The calibration may be based on artificial markers, which

are disposed at the patient's body and which can be identified in the ultrasound image data

and the 3D medical image data so that a pairing of the markers and corresponding three-

30   dimensional or spatial positions of the markers in the different image data allow to determine

a transfer function as a three-dimensional transformation in order to calibrate the position and

the image data with each other. Another possibility to calibrate the medical imaging

apparatus 10 is to identify anatomical features within the patient's body which are detectable

in the ultrasound image data and the 3D medical image data such as vessel bifurcations so

that the spatial or three-dimensional position of these identified anatomical features can be used to determine a three dimensional transformation between the different image data in order to determine the respective transfer function. The so determined transfer functions can be stored for the different calibration positions and can be utilized for a synchronization of the ultrasound image data and the three-dimensional medical image data.

The image processing unit 22 further comprises a computation unit 26 for synchronizing (real time registration) the ultrasound image data and the 3D medical image data on the basis of a position of the ultrasound probe and the plurality of calibrated transfer functions. The computation unit 26 receives the current position of the ultrasound probe 14 from the position determining unit 28 and calculates a general transfer function or a general three-dimensional transformation between the ultrasound image data at the current position and the corresponding three-dimensional medical image data in order to synchronize the ultrasound image data determined at the current position with the corresponding 3D medical image data received from the data base 20 or the imaging apparatus 10.

The image processing unit 22 determines fused image data as correlated or superimposed ultrasound image data and 3D medical image data on the basis of the synchronization received from the computation unit 26 at the current position of the ultrasound probe 14. The image processing unit 22 is connected to a display unit 28 and provides the fused image data to the display unit 28 for displaying the respectively fused image data.

Since the synchronization of the ultrasound image data and the 3D medical image data for the current position of the ultrasound probe 14 is based on the plurality of transfer functions determined at the different calibration positions of the ultrasound probe 14, the synchronization and the calibration in general can be improved so that the alignment and the synchronization of the different image data can be provided with an improved precision.

The calibration unit 24 determines at the different calibration positions a fixed or rigid three-dimensional transformation, wherein the computation unit 26 determines a general transfer function for the current position of the ultrasound probe 14 with respect to each calibration position so that the synchronization is based on the plurality of calibration transfer functions. The calibration transfer functions are weighted by means of weight factors corresponding to the respective distance of the current position of the ultrasound probe to the respective calibration positions to the general transfer function.

The different weight factors are preferably relative weight factors and have a value between 1 and 0, wherein the sum of the relative weight factors is 1. Alternatively, the

weight factors are absolute weight factors having a value of 1 or 0, wherein merely one of the weight factors is 1 and the others are 0 so that merely the transfer function of the closest calibration position is utilized.

Fig. 2 shows a schematic sectional diagram illustrating the calibration at different positions of the ultrasound probe 14 and a current position of the ultrasound probe 14.

In Fig. 2, the ultrasound probe 14 is shown together with a field of view 32 within the patient's body 12 from which the ultrasound image data is acquired as three-dimensional ultrasound data.

The different calibration positions of the ultrasound probe 14', 14" are determined with respect to a center position C_0, C_1 of the ultrasound data cone or in the center of the field of view 32', 32". Alternatively, any predefined positions within the ultrasound data cone can be defined as reference position or any position at a tip of the ultrasound probe 14 preferably a center position at the tip can be defined as reference position.

In a first step, a transfer function $T(t_0)$ linking the ultrasound image data and the 3D medical image data to each other are determined, corresponding to a spatial synchronization between the ultrasound image data and the 3D medical image data. Further, a rigid 3D transformation or a fixed 3D transformation Q_0 is determined as $Q_0 = T(t_0) / P(t_0)$, wherein $P(t_0)$ is the position of the ultrasound probe 14' at the position C_0. Corresponding to each calibration position of the ultrasound probe 14, the relationship, i.e. the transfer function between the ultrasound data and the 3D medical image data or the spatial transformation of the different image data can be written as

$$T(t) = Q_i * P(t) \hspace{4cm} (1)$$

wherein $T(t)$ is the transfer function, Q_i is the rigid or fixed transformation for the respective calibration position and $P(t)$ is the current position of the ultrasound probe 14. After the calibration at the first calibration position C_0 is performed, additional calibration steps at further positions C_1 are performed in order to achieve different calibration positions and different transfer functions $T(t_i)$.

In view of Fig. 2, two calibration transfer functions with respect to two calibration positions C_0, C_1 can be calculated linking or connecting the ultrasound data and the 3D medical image data:

$$T_{Cal0}(t) = Q_0 * P(t) \qquad\qquad (2)$$

$$T_{Cal1}(t) = Q_1 * P(t) \qquad\qquad (3)$$

wherein each of these calibration transfer functions correspond to a transfer function with respect to the respective calibration position. On the basis of these calibration transfer functions, a general transformation or a general transfer function $T(t)$ can be calculated as a convex combination of both calibration transfer functions:

$$T(t) = (1 - a)\, T_{Cal0}(t) + a\, T_{Cal1}(t) \qquad 0 \le a \le 1 \qquad (4)$$

wherein a is a weight factor considering the distance of the current position C_t of the probe 14 with respect to the two calibration positions C_0, C_1. In a generalized form, the general transformation $T(t)$ for n calibration steps and calibration positions can be expressed as:

$$T(t) = a_0 * T_{Cal0}(t) + ... + a_i\, T_{Cali}(t) + ... + a_n\, T_{Caln}(t) \qquad\qquad (5)$$

with $a_0 + ... + a_i + ... + a_n = 1$ and $a_i \ge 0$.

The general transfer functions including the weight factors a and the weighted or fixed transformation Q_n in the form of formula 1 can be expressed as:

$$T(t) = (a_0\, Q_0 + ... + a_i\, Q_i + ... + a_n\, Q_n)\, P(t) \qquad\qquad (6)$$

The weight factors a can be computed based on a distance from the center positions C_0, C_1 in the field of view 32', 32" from the current position C_t of the field of view 32. On the basis of the distance, the calibration transfer function of a calibration position which is closer to the current position used is considered more and has as a large weight in the general transformation function $T(t)$. Since the position determining unit 28 of the ultrasound probe 14 determines the position at the calibration positions C_0, C_1 and the current position, a respective distance is at any time available and the respective distance to each of the calibration positions can be computed as: $d(C_i) = d(C_i, C(t))$.

For the case that an absolute weighting of the transfer functions is utilized, the calibration positions having the smallest distance $d(C_n)$ are set to $a_n = 1$ and $a_n = 0$ otherwise.

A such absolute weighting would merely consider the calibration which has the smallest distance to the current position and would not consider all other calibration positions.

Alternatively, a relative weighting can be utilized, whereas the transfer function of the closer calibration position is considered more with a higher weight factor a and the calibration transfer function of a calibration position with a higher distance is less considered with a lower weight factor a. For the particular case of n = 2, the weights of the weight factors a are set as follows:

$$a_i = d(Cal_j) / (d(Cal_i) + d(Cal_j)) \qquad\qquad (7)$$

wherein the sum of the weight factors a_i is always set to 1.

In Fig. 3, an ultrasound image corresponding to the ultrasound image data is schematically shown in a field of view 32 of the ultrasound probe 14. The ultrasound probe 14 determines the ultrasound image data in the field of view 32, wherein in the center of the field of view 32 or the ultrasound data cone, the central position C_i is defined as a reference position of the ultrasound image data. By means of these definitions, the transfer functions and the respective synchronization of the ultrasound image data and the three-dimensional medical image data can be achieved with high precision.

Alternatively, a center position 34 at the tip of the ultrasound probe 14 can be used as a reference position for the calibration and the synchronization.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single element or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1.   Medical imaging apparatus (10) comprising:

- an ultrasound acquisition unit including an ultrasound probe (14) for acquiring ultrasound image data of a patient (12),

- an image data interface (18) for receiving 3D medical image data of the patient,

- a position determining unit (28) for determining a position of the ultrasound probe,

- a calibration unit (24) adapted to determine a transfer function between the ultrasound image data and the 3D medical image data at a plurality of positions (C) of the ultrasound probe and adapted to provide a corresponding plurality of calibrated transfer functions (T_{Cal0}, T_{Cal1}) and calibration positions, and

- a computation unit (26) adapted to synchronize the ultrasound image data and the 3D medical image data on the basis of a position of the ultrasound probe and the plurality of calibrated transfer functions, said computation unit is further adapted to weight the calibrated transfer functions on the basis of a position of the ultrasound probe.

2.   Medical imaging apparatus as claimed in claim 1, wherein the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance between the ultrasound probe and the plurality of calibration positions.

3.   Medical imaging apparatus as claimed in claim 2, wherein the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance between a predefined position (34) at a tip of the ultrasound probe and a plurality of the calibration positions.

4.   Medical imaging apparatus as claimed in claim 2, wherein the computation unit is adapted to weight the calibrated transfer functions on the basis of a distance (d) between a predefined position within the ultrasound image data and a plurality of calibration positions.

5.   Medical imaging apparatus as claimed in claim 4, wherein the predefined position within the ultrasound image data is a centre of the ultrasound image data.

5   6.   Medical imaging apparatus as claimed in claim 1, wherein the computation unit is further adapted to weight the calibrated transfer functions by means of relative weight factors (a).

7.   Medical imaging apparatus as claimed in claim 1, wherein the computation

10   unit is further adapted to weight the calibrated transfer functions on the basis of absolute weight factors (a).

8.   Medical imaging apparatus as claimed in claim 1, wherein the calibration unit is further adapted to determine a 3D rigid transformation (Q) for each calibration position.

15

9.   Medical imaging apparatus as claimed in claim 1, wherein the computation unit is further adapted to determine a general transfer function (T) for a current position of the ultrasound probe on the basis of the calibrated transfer functions weighted by weight factors.

20

10.   Medical imaging apparatus as claimed in claim 1, further comprising an image processing unit (22) for providing fused image data and on the basis of the synchronized ultrasound image data and 3D medical image data and an image data interface for providing the fused image data to a display unit (28).

25

11.   Medical imaging method for combining different medical image data, comprising the steps of:

          - acquiring ultrasound data of a patient (12) by means of an ultrasound probe (14),

30   - receiving 3D medical image data of the patient,

          - determining a position of the ultrasound probe by means of a position determining unit (28),

          - determining a transfer function between the ultrasound image data and the medical image data at a plurality of positions of the ultrasound probe and providing a

corresponding plurality of calibrated transfer functions and calibration positions, and

- synchronizing the ultrasound image data and the 3D medical image data on the basis of a position of the ultrasound probe and the plurality of transfer functions.
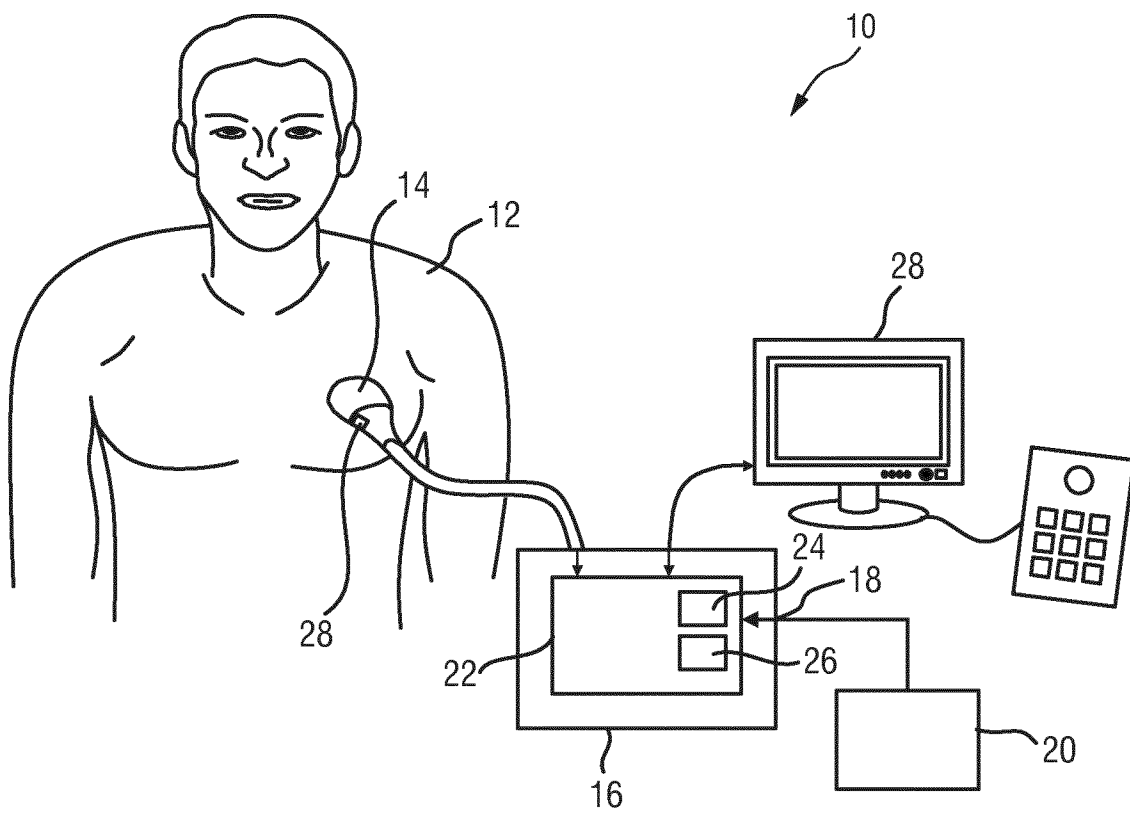
FIG.1

FIG.2
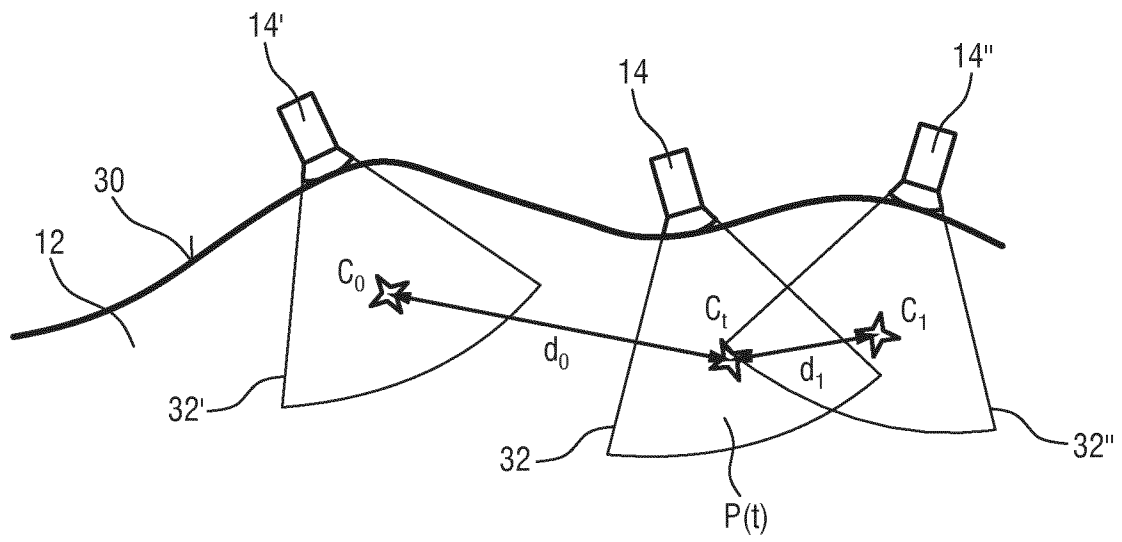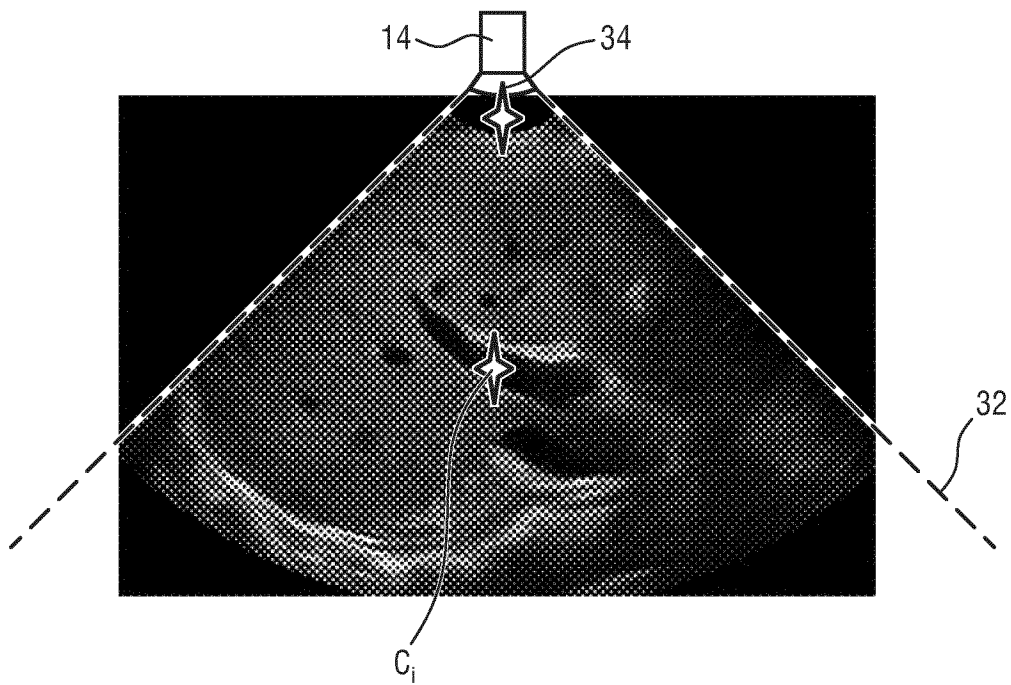

FIG.3

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B8/00   A61B6/00   A61B8/08   G06T7/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/193053 A1 (KADOURY SAMUEL [US] ET AL) 10 July 2014 (2014-07-10)	11
A	abstract figures 1-7 paragraph [0034] - paragraph [0098] -----	1-10
X	US 2012/215093 A1 (JI SONGBAI [US] ET AL) 23 August 2012 (2012-08-23)	11
A	abstract figures 1-5 paragraph [0026] - paragraph [0066] -----	1-10
X	EP 2 279 695 A1 (MEDISON CO LTD [KR]; KOREA ADVANCED INST SCI & TECH [KR]) 2 February 2011 (2011-02-02)	11
A	abstract figures 1-5 claims 1-12 -----	1-10

-/--

| X | Further documents are listed in the continuation of Box C. | X | See patent family annex. |

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 July 2016	04/08/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Moehrs, Sascha

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WOLFGANG WEIN ET AL: "Integrating Diagnostic B -Mode Ultrasonography Into CT-Based Radiation Treatment Planning", IEEE TRANSACTIONS ON MEDICAL IMAGING, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 26, no. 6, 2 June 2007 (2007-06-02), pages 866-879, XP011184851, ISSN: 0278-0062, DOI: 10.1109/TMI.2007.895483 abstract figures 1-8 Sections II - IV -----	1-11

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 2014193053	A1	10-07-2014	CN	103402453 A	20-11-2013
			EP	2680778 A1	08-01-2014
			US	2014193053 A1	10-07-2014
			WO	2012117381 A1	07-09-2012
US 2012215093	A1	23-08-2012	US	2012215093 A1	23-08-2012
			WO	2011025943 A2	03-03-2011
EP 2279695	A1	02-02-2011	EP	2279695 A1	02-02-2011
			JP	5606203 B2	15-10-2014
			JP	2011031042 A	17-02-2011
			KR	20110013036 A	09-02-2011
			US	2011026796 A1	03-02-2011
			US	2015289855 A1	15-10-2015
			US	2016007974 A1	14-01-2016