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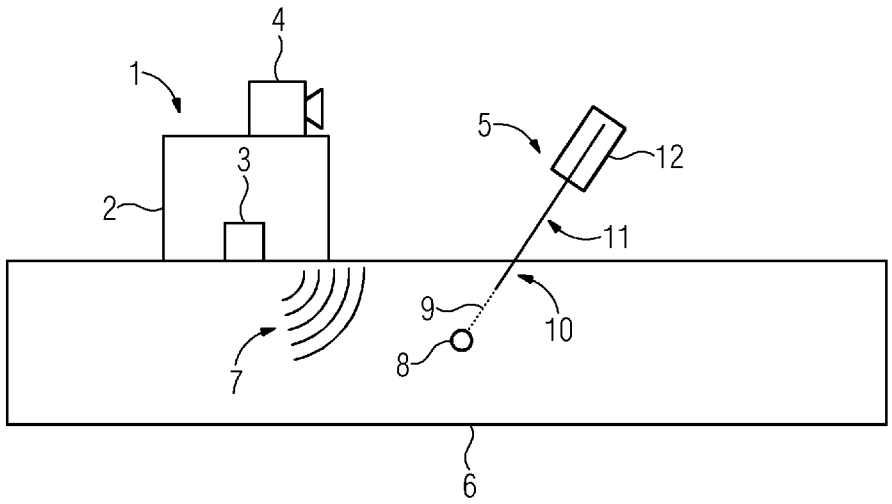
(54) **Title:** SENSING DEVICE AND METHOD FOR TRACKING A NEEDLE BY MEANS OF ULTRASOUND AND A FURTHER SENSOR SIMULTANEOUSLY

FIG 1



(57) **Abstract:** The invention relates to a sensing device (1) for providing guidance for a medical device (5), in particular a needle, comprising - a probe housing (2) and - an ultrasound sensor (3), which is at least partly surrounded by the probe housing (2), for acquiring target information concerning a medical target (6) by means of ultrasound (7), - wherein the sensing device (1) is configured to provide the target information for providing guidance in positioning the medical device (5), in particular the needle, relative to the medical target (6). To improve the tracking of the medical device (5), in particular the needle, it is envisaged that - a sensor unit (4) which is directly arranged at the probe housing (2), wherein the sensor unit (4) is configured to acquire position data concerning a position of the medical device (5), in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor (3).

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Description

Sensing device and method for tracking a needle by means of ultrasound and a further sensor simultaneously

The invention relates to a sensing device for providing guidance for a medical device, in particular a needle. Another aspect of the invention relates to a method for providing guidance for a medical device, in particular a needle.

Medical devices, for example needles, screws or K-wires, have to be placed very carefully in relation to a medical target or a clinical target. Such a medical target could in an example be a patient or a dummy for simulating the patient. If the medical device is a needle it can for example be introduced into the medical target. In doing so the medical device, in particular the needle, is supposed to follow a previously planned trajectory. The trajectory for the medical device, in particular the needle, can be planned beforehand on the basis of previously gained information about the medical target. Such can for example be an ultrasonic image, an X-ray image, a computer tomography or a magnetic resonance image. In a concrete example the needle is supposed to be introduced to a target within the dummy, wherein the target simulates a tumor inside the dummy. Of course precise positioning of a medical device is crucial in many other use cases as well.

In this context guidance means for needles may be used. This can for example be done on the basis of two-dimensional ultrasound. Unfortunately the needle cannot be tracked properly by means of two-dimensional ultrasound because the needle is only detected whenever it crosses an ultrasound plane. Even when turning to three-dimensional ultrasound the needle can hardly be tracked properly due to echoes and insufficient resolution.

It is an object of the present invention to improve the tracking of a medical device, in particular a needle.

This object is solved by the subject-matter of the independent claims. Advantageous embodiments are part of the dependent claims.

A first aspect of the invention relates to a sensing device for providing guidance for a medical device, in particular a needle, comprising
- a probe housing, and
- an ultrasound sensor, which is at least partly surrounded by the probe housing, for acquiring target information concerning a medical target by means of ultrasound,
- wherein the sensing device is configured to provide the target information for providing guidance in positioning the medical device, in particular the needle, relative to the medical target.

To solve the above-mentioned task the sensing device comprises a sensor unit which is directly arranged at the probe housing, wherein the sensor unit is configured to acquire position data concerning a position of the medical device, in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor.

A second aspect of the invention relates to a method for providing guidance for a medical device, in particular a needle, comprising the following steps:
- acquiring target information concerning a medical target by means of ultrasound by an ultrasound sensor arranged at least partly inside a probe housing,
- acquiring position data concerning a position of the medical device, in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor, by a sensor unit, which is directly arranged at the probe housing,

- providing guidance in positioning the medical device, in particular the needle, relative to the medical target by means of the target information and the position data.

The probe housing can be formed as a handheld device. For acquiring the target information the probe housing can be configured to directly couple the ultrasound sensor to the medical target. For example the probe housing may partly be opened to allow acoustical and/or mechanical coupling between the ultrasound sensor and the medical target. Alternatively or additionally the probe housing may contain a membrane to allow said coupling.

The ultrasound sensor and the sensor unit are mounted on the probe housing. The ultrasound sensor is arranged at least partly inside the probe housing. The sensor unit may be arranged at the inside or the outside of the probe housing. Advantageously the sensor unit is arranged at least partly inside the probe housing. In both cases the sensor unit can be in direct touch with the probe housing. By the probe housing a relative position of the sensor unit in relation to the ultrasound sensor may be fixed. In other words, the probe housing provides a defined and fixed relative position between the ultrasound sensor and the sensor unit. This may apply to all parts of the ultrasound sensor and/or the sensor unit respectively. In other words the position of every part of the sensor unit in relation to the ultrasound sensor may be fixed or determined by the probe housing. Additionally or alternatively the position of the sensor unit in relation to the probe housing may be fixed. Advantageously the position of each part of the sensor unit in relation to the probe housing is fixed.

By said relative positions it is ensured that respective detection ranges of the sensor unit and the ultrasound sensor can be aligned to each other. In other words, respective coordinate systems of the ultrasound sensor and the sensor unit can be aligned to each other.

The target information provided by the sensing device may be used for positioning the sense device or the probe housing respectively in relation to the medical target. In particular the sensing device or the probe housing respectively may be positioned relative to a desired position for the medical device at the medical target. If the medical device is a needle, the sensing device or the probe housing respectively may be positioned according to a planned trajectory for the needle. Alternatively or additionally a so-called registration may be carried out. In the scope of the registration the target information may be compared or matched with previously acquired target information. For example a two-dimensional or three-dimensional ultrasound image which is part of the target information is compared or matched with a previously acquired two-dimensional or three-dimensional image of the medical target. In doing so the relative position of the sensing device or the probe housing respectively in relation to the desired position for the medical device in particular the planned trajectory for the needle may be determined.

The sensor unit can be configured to measure the position or a pose respectively of the medical device, or of at least one section of the medical device. The medical device can in particular be a needle. Therefore the sensor unit or the sensing device respectively may be configured to track the medical device on its way to the desired position. In particular the sensing device or the sensor unit respectively may be configured to track the needle along the planned trajectory. The position or pose of the medical device may be set into context with the desired position. In particular the position, pose or movement of the needle may be set into context with the orientation, pose or position of the planned trajectory. A difference between the desired position and the medical device or in particular the planned trajectory and the needle, may be provided as information. Based on this information a refined positioning or introducing of the needle can be allowed.

In an embodiment the sensing device is also configured to acquire further position data concerning a position of the medical device by means of the ultrasound sensor, wherein the further position data concerns the position only of an introduced part of the medical device, which is introduced into the medical target. In another embodiment the further position data concerning the position of the medical device is acquired by means of the ultrasound sensor. That further position data may concern the position only of an introduced part of the medical device, which is introduced into the medical target. In other words when acquiring an image of the medical target by the ultrasound sensor, such an image can be used for determining the further position data. For example an ultrasound image of the medical target with the introduced part of the medical device is acquired. The further position data can then be extracted from that image, for example on the basis of measurements in the image.

Based on the position data and the further position data refined position data may be determined. In other words the position data acquired by the sensor unit and the further position data acquired by means of ultrasound can be merged or joined. In doing so systematic or statistic errors in determining the position of the medical device can be reduced or suppressed.

For example, the position data acquired by the sensor unit concerns the position only of a part of the medical device, which is outside the medical target. In other words the position data acquired by the sensor unit may concern the position of a non-introduced part of the medical device only. The non-introduced part of the medical device can be that part of the medical device which is not or not yet introduced into the medical target. As mentioned above the further position data acquired by means of ultrasound can concern the position of the introduced part of the medical device only. In this case the position of the medical device is acquired only out-

side the medical target by means of the sensor unit. Analogously the position of the medical device may be determined by means of ultrasound only inside the medical target. In combining both, the position data and the further position data, respective position data from inside or outside the medical target respectively can be merged.

In a further embodiment extrapolated position data concerning the position of the introduced part of the medical device is determined by means of extrapolation on the basis of the position data. In other words the position data acquired by the sensor unit may be extrapolated to gather or gain the extrapolated position data. In other words the position data concerning the non-introduced part of the medical device may be extrapolated to gain information concerning the position of the introduced part of the medical device. The extrapolated position data may be merged or set in context with the further position data acquired by means of ultrasound. In doing so the position of the introduced part of the medical device may be acquired with higher accuracy.

The extrapolation can be carried out additionally on the basis of at least one of the following additional inputs: dimensions of the medical device, elasticity or bending properties of the medical device and a planned path for the medical device. One or more of the additional inputs may be used additionally to the position data. The additional inputs may be received from a data base. The data base may contain previously measured values for one or more of the additional inputs. Alternatively the additional inputs may be acquired from a manufacturer or distributer of the medical device. By the extrapolation based on the additional inputs an accuracy may be further improved.

By means of the extrapolation a position of a tip of the medical device which is formed as the needle can be determined. In other words the position of the tip of the needle may be determined by means of the extrapolation from the non-

introduced part of the needle. Therefore, the additional inputs may comprise information about dimensions of the needle, and in particular a length of the needle. In doing so it can be determined how far and where the needle extends into the medical target on the basis of the non-introduced part.

In a further step of the present method a previously acquired image of the medical target is received and a two-dimensional or three-dimensional registration of an ultrasound image acquired as part of the target information is carried out. In other words the ultrasound image may be acquired as part of the target information. This ultrasound image may then be used for registration on the basis of a previously acquired image. The previously acquired image may be received from a further ultrasound device, an X-ray device, in particular a C-arm, or from a computer tomograph. In other words the previously acquired image may be acquired by means of ultrasound, X-ray, computer tomography, magnetic resonance therapy or any other imaging method. The previously acquired image may be two-dimensional or three-dimensional. A planned position and/or path of the medical device defined in the coordinate space of the previously acquired image may also be received.

Within the scope of the registration a position of the sensing device, the probe housing or the ultrasound sensor relative to the medical target may be compared or set into context with the previously acquired image. In particular the desired position and/or path for the medical device may be determined on the basis of the registration. In doing so the correct positioning of the medical device can be verified or guided. In an embodiment the probe housing is formed as a handheld device which comprises the ultrasound sensor and the sensor unit. In other words, the probe housing, the ultrasound sensor and the sensor unit together form a handheld device. This allows a very easy handling of the present sensing device. For making use of the sensing device the probe housing can be placed freely on the medical target. Its correct

relative position to the medical target is then determined within the scope of the registration.

In an embodiment the sensor unit comprises a camera, a stereo camera, a time of flight camera (TOF-camera), a LIDAR sensor or an electromagnetic sensor. The electromagnetic sensor may be part of an electromagnetic tracking system which is well known within the scope of the medical technology. The camera or the stereo camera may be part of an optical tracking system which is also well known in the scope of medical technology. The camera, the stereo camera or the electromagnetic sensor can be configured to capture a pattern or additional sensor which is attached to the medical device. The pattern is attached to the medical device in order to facilitate the determination of the position of the medical device or improve the accuracy thereof.

For example the pattern may comprise one or more of the following: alignment marks like lines, circles or symbols on the surface of the medical device, reflective surface or reflective patterns on the medical device or fluorescent markings on the surface of the medical device. The alignment marks allow the determination of the precise distance from the marks to the sensor unit and/or from the marks to the needle tip of the needle. In this determination known sizes or properties of the alignment marks may be used and/or a known spacing between different alignment marks may be analyzed. With parts of the pattern being fluorescent an accuracy of determination can be further increased. In particular a signal to noise ratio may be increased. In the fluorescent surface light of a first wavelength is absorbed and then again transmitted with a different second wavelength. The sensor device may emit light of the first wavelength and capture the light of the second wavelength to acquire the position data concerning the position of the medical device. The pattern may be formed detachable from the medical device. For example the pattern may be formed as a clip-on adapter.

In an embodiment the sensor unit comprises a guiding means arranged at the probe housing to indicate the planned path by optical means and/or to give physical guidance to the medical device along the planned path. In other words the guiding means can be configured to highlight the planned path. Therefore the guiding means can comprise a projector, for example a light unit or a laser unit. Such is described in the patent application from Siemens with the Siemens reference number 201900798. Alternatively or additionally the guiding means can be configured to give physical guidance to the medical device along the planned path. For example the physical guidance comprises a mechanical guideline.

A third aspect of the invention relates to a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the following steps:
- commanding an ultrasound sensor arranged at least partly inside a probe housing to acquire target information regarding a medical target by means of ultrasound,
- commanding a sensor unit, which is directly arranged at the probe housing, to acquire position data regarding a position of a medical device by means of an acquisition principle, which is different from the ultrasound sensor,
- receiving the target information and the position data for providing guidance in positioning a medical device relative to the medical target under consideration of the relative position of the ultrasound sensor and the sensor unit.

The computer program may be stored on a computer readable medium, for example a hard disk, a flash medium or an optical storage medium. The computer readable medium may comprise instructions which, when the program is executed by a computer, cause the computer to execute the claimed method.

Embodiments which are disclosed for the sensing device apply analogously to the method for providing guidance for a medical device as well as to the computer program. Conversely em-

bodiments and their benefits disclosed for the method or the computer program also apply for the sensing device. All embodiments and features which are disclosed in the scope of the present application can be combined if useful or used on their own. In the following an exemplary embodiment is described on the basis of the drawings. Therein show:

FIG 1 schematically a sensing device in an intended use case together with a needle and a medical target; and

FIG 2 an exemplary flow chart of a method for providing guidance for a medical device.

FIG 1 shows a sensing device 1 which comprises a probe housing 2, an ultrasound sensor 3 and a sensor unit 4. The ultrasound sensor 3 is at least partly surrounded by the probe housing 2. In the present embodiment the ultrasound sensor 3 is arranged completely inside the probe housing 2. The sensor unit 4 is arranged directly at the probe housing 2. The sensor unit 4 can be arranged inside the probe housing 2, outside the probe housing 2 or partly inside and outside the probe housing 2. By the probe housing 2 a relative position of the ultrasound sensor 3 and the sensor unit 4 is fixed. In other words the probe housing 2 is configured to provide a fixed relative position between the ultrasound sensor 3 and the sensor unit 4.

The ultrasound sensor 3 is configured to provide target information concerning a medical target 6. The target information may comprise a two-dimensional or three-dimensional ultrasound image of the medical target 6. The acquiring of the target information is carried out by means of ultrasound 7. The ultrasound sensor 3 is configured to emit ultrasound 7 into the medical target 6, when mechanically or acoustically coupled to the medical target 6.

On the basis of the target information the sensing device 1 or the probe housing 2 respectively can be positioned on the

medical target 6 in an intended way. The sensing device 1 is configured to provide the target information to allow the intended positioning of the sensing device 1 relative to the medical target 6. This positioning can be carried out within the scope of a so-called registration. Within the registration the target information can be compared to a previously acquired image of the medical target 6. The previously acquired image can be a two-dimensional or three-dimensional ultrasound image, an X-ray image, a computer tomography or a magnetic resonance image. On the basis of this comparison the relative position of the sensing device 1 or the probe housing 2 respectively relative to the medical target 6 can be determined. For example the sensing device 1 may comprise a memory for storing the previously acquired image or an interface for receiving the previously acquired image.

The medical target 6 may be a human body, in particular a patient, or a dummy for simulating the patient or a human body respectively. Such a dummy may be intended for teaching purposes. Within the medical target 6 there is an intended position for a medical device 5. The medical device 5 may be a needle with its tip supposed to be introduced to the intended position 8. For example the intended position 8 can be a tumor within the human body or a representation of the tumor within the dummy. The sensing device 1 is configured to provide the target information for providing guidance in positioning the medical device 5 relative to the medical target 6. In particular the sensing device 1 is configured to provide the target information for providing guidance in positioning or introducing the needle into the medical target 6. This guidance may entail validating the correct positioning of the medical device 5 and/or a correct path for the medical device 5. In the present example the needle as the medical device 5 is intended to be introduced into the medical target 6 along a needle trajectory or an intended path 9 respectively. Therefore the sensing device 1 acquires position data regarding the position of the medical device 5. This is carried out by two different acquisition principles.

The position data is partly acquired by the ultrasound sensor 3. In particular position data regarding an introduced part 10 of the medical device 5 is acquired by means of the ultrasound sensor 3. The introduced part 10 is the part of the medical device 5 which is already introduced into the medical target 6.

Another part of the position data is acquired by means of the sensor unit 4. This part of the position data is also referred to as further position data. The further position data is acquired by the sensor unit 4 by means of an acquisition principle which is different from the acquisition principle of the ultrasound sensor 3. For example the sensor unit 4 may comprise a stereo camera, a mono camera, a LIDAR sensor, a time-of-flight camera (TOF-camera), a red-green-blue-depth-camera module (RGBD) or an electromagnetic sensor. The electromagnetic sensor can be part of an electromagnetic tracking system which is well-known in the scope of medical technology. The electromagnetic tracking system can also comprise a counterpart which is attached to the medical target or attachable to the medical target 6. By means of the sensor unit 4 position data regarding the position of the medical device outside the medical target 6 can be acquired. In other words the position data acquired by the sensor unit 4 may regard the position only of a non-introduced part 11 of the medical device 5. To ease the acquiring of the position data a pattern 12 may be attached or be attachable to the medical device 5. The pattern 12 may comprise alignment marks, a reflective surface and/or a fluorescent surface. The pattern 12 may be captured by the sensor unit 4 to allow a precise determination of the medical device 5 and/or to facilitate the determination of the three-dimensional orientation of the medical device 5. Especially the alignment marks may allow the determination of the precise distance from the alignment marks to a needle tip of the needle as the medical device 5. Therefore the alignment marks have to be attached to the medical device, in particular the needle, in a predefined rela-

tive position to the needle tip. In other words the alignment marks allow the determination of the length of the introduced part 10 of the medical device 5. Fluorescent surfaces which emit light of a different wave length when illuminated with an illumination wave length can be used for allowing a more precise determination of the position of the medical device 5. In particular by the use of fluorescent surfaces a signal to noise ratio can be reduced.

On the basis of the position data regarding the non-introduced part 11 of the medical device 5 an extrapolation can be carried out. Within the scope of the extrapolation extrapolated position data regarding the position of the introduced part 10 or the needle tip respectively can be acquired. As input for the extrapolation one or more of the following additional inputs may be used: Length of the needle, elasticity and/or bending properties of the needle and the planed needle path. The length of the needle may be received from a user input, a selection of a pre-calibrated needle type or by a previously acquired image, in particular a two-dimensional or three-dimensional image, of the needle. The image of the needle may be an optical picture. The elasticity or bending properties of the needle may be acquired from a data base. For example a user selection of a specific needle type from the data base is received. Analogously the length of the needle may be acquired from such a data base and the user selection. By means of the extrapolation the length of the introduced part 10 of the needle, an estimation of a bending of the needle inside the medical target 6 and/or an estimation of a needle trajectory inside the medical target 6 can be determined. The estimation of the needle trajectory may be carried out under the assumption of no bending of the needle or with taking the above-mentioned estimation of the needle bending into account. The estimation of the needle bending inside the medical target 6 may be carried out on the basis of the elasticity and/or bending properties. Additionally or alternatively the estimation of the needle bending may be carried out by evaluating a needle bending of the non-

introduced part 11 of the needle. Therefore the needle bending of the non-introduced part 11 may be acquired as part of the position data. The length of the introduced part 10, the estimation of the needle bending inside the medical target 6 and/or the estimation of the needle trajectory inside the medical target 6 can be provided as part of the position data.

To further improve an accuracy of the medical device 5, the position data acquired by means of the ultrasound sensor 3 and the position data acquired by means of the sensor unit 4 can be merged. For example a position of the needle tip determined on the basis of the position data from the sensor unit 4 may be compared to a position of the needle tip determined from the position data acquired by the ultrasound sensor 3. In combining or merging both position data and both determined positions of the needle tip refined position data or a refined position of the needle tip may be acquired.

The position of the medical device 5 or the needle tip respectively can be provided for providing guidance in positioning the medical device 5. For example the determined position of the medical device or the needle tip respectively can be transmitted to a monitoring device, for example a monitor, a flat screen or any kind of display. The display device can be part of the sensing device 1. The display device may be connected to the probe housing by a data cable or a wireless connection. The previously taken image of the medical target 6 can also be displayed on the display device. Advantageously an overlay from the previously taken image of the medical target 6 and the previously taken image of the medical device 5, in particular the needle, is generated. In this overlay the position of the medical device relative to the medical target 6 and/or relative to the planned path 9 and/or relative to the intended position 8, in particular the position of the needle tip inside the medical target 6, can be visualized. Therefore the previously taken image of the medical device 5 is displayed within relative position to the

previously taken image of the medical target 6, which corresponds to the position of the medical device 5 inside the medical target 6.

FIG 2 shows a method for providing guidance for a medical device, in particular a needle, comprising the following steps:
S1: acquiring target information concerning a medical target by means of ultrasound by an ultrasound sensor arranged at least partly inside a probe housing,
S2: acquiring position data concerning a position of the medical device, in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor, by a sensor unit, which is directly arranged at the probe housing, and
S3: providing guidance in positioning the medical device, in particular the needle, relative to the medical target by means of the target information and the position data.

Claims

1. Sensing device (1) for providing guidance for a medical device (5), in particular a needle, comprising
- a probe housing (2) and
- an ultrasound sensor (3), which is at least partly surrounded by the probe housing (2), for acquiring target information concerning a medical target (6) by means of ultrasound (7),
- wherein the sensing device (1) is configured to provide the target information for providing guidance in positioning the medical device (5), in particular the needle, relative to the medical target (6),
- wherein a sensor unit (4) is directly arranged at the probe housing (2), wherein the sensor unit (4) is configured to acquire position data concerning a position of the medical device (5), in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor (3).

2. Sensing device (1) according to claim 1, characterized in that the sensing device (1) is also configured to acquire further position data concerning a position of the medical device (5) by means of the ultrasound sensor (3), wherein the further position data concerns the position only of an introduced part (10) of the medical device (5), which is introduced into the medical target (5).

3. Sensing device (1) according to one of the preceding claims, characterized by a guiding means arranged at the probe housing (2) to indicate the planned path (9) by optical means and/or to give physical guidance to the medical device (5) along the planned path (9).

4. Sensing device (1) according to one of the preceding claims, characterized in that the probe housing (2) forms a handheld device comprising the ultrasound sensor (3) and the sensor unit (4).

5. Sensing device (1) according to one of the preceding claims, characterized in that the sensor unit (4) comprises a camera, a stereo-camera, a time-of-flight camera, a LIDAR sensor or an electromagnetic sensor.

6. Method for providing guidance for a medical device (5), in particular a needle, comprising the following steps:
- acquiring target information concerning a medical target (6) by means of ultrasound (7) by an ultrasound sensor (3) arranged at least partly inside a probe housing (2),
- acquiring position data concerning a position of the medical device (5), in particular the needle, by means of an acquisition principle, which is different from the ultrasound sensor (3), by a sensor unit (4), which is directly arranged at the probe housing (2),
- providing guidance in positioning the medical device (5), in particular the needle, relative to the medical target (6) by means of the target information and the position data.

7. Method according to claim 6, characterized in that further position data concerning the position of the medical device (5) is acquired by means of the ultrasound sensor (3).

8. Method according to claim 7, characterized in that the further position data concerns the position only of an introduced part (10) of the medical device (5), which is introduced into the medical target (6).

9. Method according to one of the claims 6 to 8, characterized in that the position data concerns the position only of a part of the medical device (5), which is outside the medical target (6).

10. Method according to one of the claims 6 to 9, characterized in that extrapolated position data concerning the position of the introduced part (10) of the medical device (5), which is introduced into the medical target (6), is deter-

mined by means of extrapolation on the basis of the position data.

11. Method according to claim 10, characterized in that the extrapolation is carried out additionally on the basis of at least one of the following additional inputs: dimensions of the medical device (5), elasticity or bending properties of the medical device (5) and a planned path for the medical device (5).

12. Method according to claim 10 or 11, characterized in that by means of the extrapolation a position of a needle tip of the medical device (5) which is formed as a needle is determined.

13. Method according to one of the claims 6 to 12, characterized in that refined position data is determined from the position data and the further position data.

14. Method according to one of the claims 6 to 13, characterized in that a previously acquired image of the medical target is received and a two-dimensional or three-dimensional registration of an ultrasound image acquired as part of the target information is carried out.

15. Computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the following steps:
- commanding an ultrasound sensor (3) arranged at least partly inside a probe housing (2) to acquire target information concerning a medical target (6) by means of ultrasound,
- commanding a sensor unit (4), which is directly arranged at the probe housing (2), to acquire position data concerning a position of a medical device (5) by means of an acquisition principle, which is different from the ultrasound sensor (3),
- receiving the target information and the position data for providing guidance in positioning a medical device (5) relative to the medical target (6) under consideration of the

relative position of the ultrasound sensor (3) and the sensor unit (4).

FIG 1

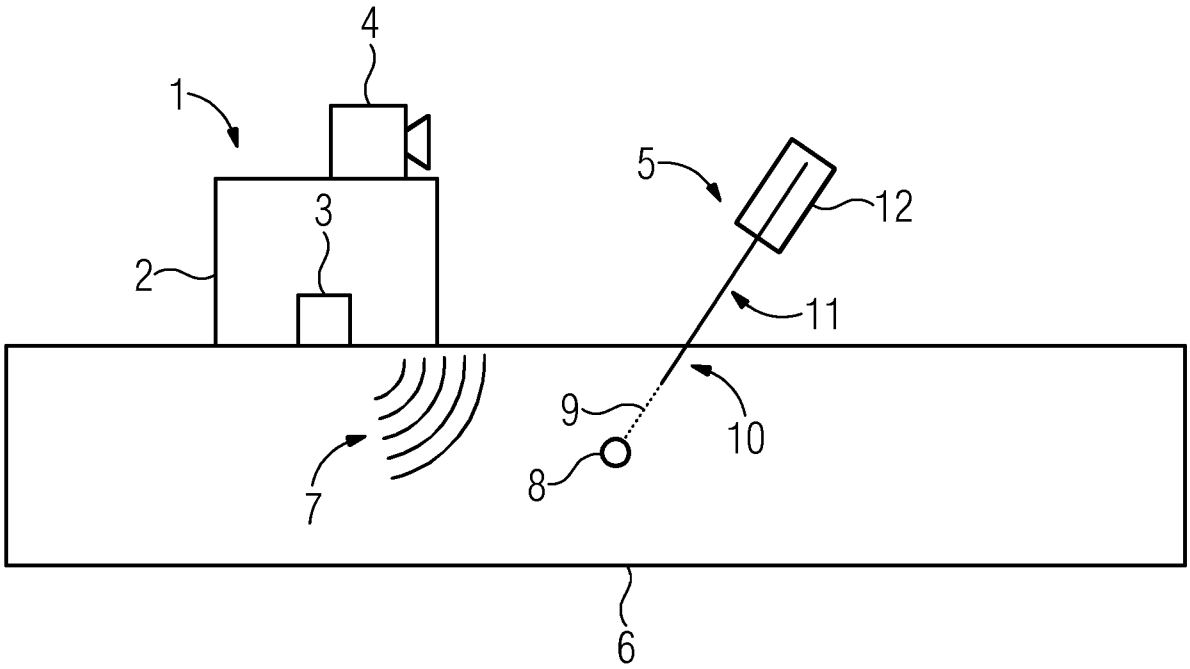
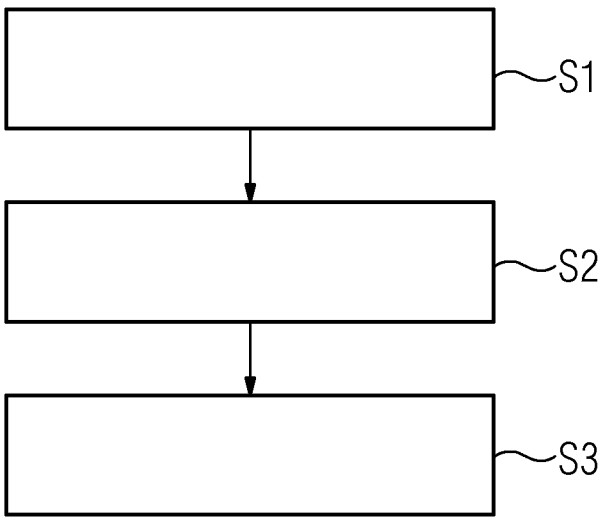


FIG 2



INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
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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

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	DE 10 2011 010412 A1 (MEIER BERND H [DE]) 9 August 2012 (2012-08-09) claims 1-9; figures 1-3	1-15
X	WO 2004/019799 A2 (COMPUTERIZED MED SYST INC [US]; BURDETTE EVERETTE C [US] ET AL.) 11 March 2004 (2004-03-11) page 10, line 30 - page 13, line 15; figures 1,2 page 14, line 36 - page 16, line 3	1-15
X	WO 2011/063266 A2 (UNIV JOHNS HOPKINS [US]; STOLKA PHILIPP JAKOB [US] ET AL.) 26 May 2011 (2011-05-26) paragraphs [0040] - [0048], [0063]; figure 8	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2019	08/11/2019

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	Nurmi, Jussi

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/055880

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		US 2012253200 A1	04-10-2012
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