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Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: MULTI-LEG GEOMETRY REFERENCE TRACKER FOR MULTI-MODALITY DATA FUSION

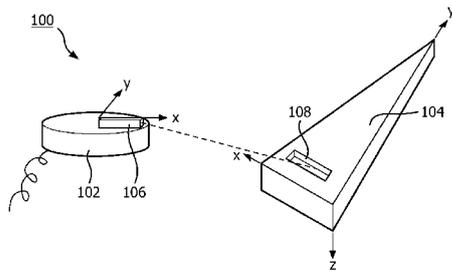


FIG. 1A

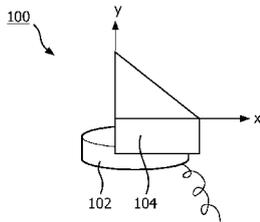


FIG. 1B

(57) Abstract: A reference tracker, system and method include a tracker portion (102) having a coordinate system encoded therein against which a medical device is tracked. A base portion (104) is associated with the tracker portion. The base portion has a geometry configured to coincide with two axes of the coordinate system to provide a visible indicator of the coordinate system in an anatomical image to permit registration between the anatomical image and the coordinate system.



- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- Published:**
- *with international search report (Art. 21(3))*

MULTI-LEG GEOMETRY REFERENCE TRACKER FOR MULTI-MODALITY DATA FUSION

This disclosure relates to medical imaging, and more particularly to a reference tracker, tracking system and method which employ the reference tracker geometry to permit data fusion from different imaging modalities.

Electromagnetic (EM) tracking has proven to be a useful tool for many minimally invasive interventions and surgeries. Intra-operative real time imaging modalities (such as x-ray, endoscope, ultrasound) are linked with pre-operative imaging modalities (such as, computed tomography (CT), magnetic resonance imaging (MRI), etc.), via the aid of EM tracking, so that the pre-operative roadmap can be utilized to assist guidance with the real-time imaging.

In one example, assume a pre-operative imaging space is CT space. One procedure for EM guided endoscopy intervention is to align EM space with pre-operative CT space. Two major types of registration methods are implemented for this: (1) external fiducial based registration, and (2) internal fiducial based registration.

For either fiducial registration type, all the fiducials are identified in CT space; then they are touched by an EM tracker to acquire their EM coordinates (using the reference tracker as the global reference coordinate system). Through a point-based registration algorithm, the two spaces are aligned together. The EM-CT registration matrix always remains valid no matter how much movement patients may undergo in the EM field. This is because with the introduction of the reference tracker, all the tracking data are relative to the reference tracker, not to a field generator for the tracker.

The fiducial based registration is a cumbersome and error-prone procedure (fiducial

localization error in CT and EM may contribute to registration error). In addition, skin fiducials are not always available in pre-operative images because some of these images are acquired before the decision is made for performing the procedure. These pre-operative images are therefore not usable, and patients have to undergo additional radiological scans with attached fiducials on the skin. In other instances, a field of view of pre-operative imaging (such as pre-operative transrectal MRIs that are employed to fuse with intra-operative transrectal ultrasound (TRUS)) is not large enough to cover all of the fiducials placed on the skin. This can result in registration errors and difficulty in tracking operative instruments, among other drawbacks.

Fiducial-based registration has disadvantages that do not exist for some more sophisticated image-based registrations, which merge pre-operative and intra-operative modalities. However, image-based registration is difficult to implement under real-time requirements and is plagued with various image artifacts.

In accordance with the present principles, a new reference tracker is disclosed which includes a tracker portion having a coordinate system encoded therein against which a medical device is tracked. A base portion is associated with the tracker portion. The base portion has a geometry configured to coincide with two axes of an electromagnetic (EM) tracking coordinate system to provide a visible indicator of the coordinate system in an anatomical image to permit registration between the anatomical image and the EM tracking coordinate system.

A reference tracker includes a tracker portion having a coordinate system encoded therein against which a medical device is tracked. A base portion is associated with the tracker portion. The base portion has a geometry configured to coincide with at least two axes of the coordinate system to provide a visible indicator of the coordinate system in an

anatomical image to permit registration between the anatomical image and the coordinate system.

A system includes a tracking system and a reference tracker. The reference tracker includes a tracker portion having a coordinate system encoded therein, the coordinate system defining coordinate for the tracking system; and a base portion associated with the tracker portion, the base portion having a geometry configured to coincide with at least two axes of the coordinate system and formed from a material to provide a visible indicator of the coordinate system in an anatomical image to permit registration between the anatomical image and the coordinate system. An imaging system is configured to generate the anatomical image.

A method for registering a tracking system with an image includes providing a reference tracker including a tracker portion having a coordinate system encoded therein, and a base portion associated with the tracker portion, the base portion having a geometry configured to coincide with at least two axes of the coordinate system. The method may further include attaching the reference tracker to a subject; imaging the subject with the reference tracker visible in the image; and registering the coordinate system with image space of the image.

These and other objects, features and advantages of the present disclosure will become apparent from the following detailed description of illustrative embodiments thereof, which is to be read in connection with the accompanying drawings.

This disclosure will present in detail the following description of preferred embodiments with reference to the following figures wherein:

FIG. 1A is a perspective view of a top of a tracker portion and a bottom of a base portion of a reference tracker device separated to show connection details in accordance with

one embodiment;

FIG. 1B is an assembled perspective view of the tracker portion and the base portion of the reference tracker device of FIG. 1A in accordance with one embodiment;

FIG. 2 is a perspective view of an integrated reference tracker device having a tracker portion and a base portion formed together in accordance with one embodiment;

FIG. 3 is a block/flow diagram showing a system for performing a procedure with a reference tracker in accordance with the present principles;

FIG. 4 is a side schematic view or image of a subject having a reference tracker attached to define a coordinate system in accordance with the present principles; and

FIG. 5 is a block/flow diagram showing a method for performing a procedure with a reference tracker in accordance with the present principles.

The present disclosure describes a reference tracker, e.g., an electromagnetic (EM) reference tracker that facilitates multi-modality data registration. The present principles eliminate the need for fiducial-based registrations by integrating tracking information into a geometry of the reference tracker. Commercially available reference trackers typically have a sphere or disk with about a 2 cm diameter. The local coordinates of such trackers are unknown and need to be measured. Since the end goal of registration (e.g., EM to CT registration) is to find a transformation matrix between a CT origin and the EM reference tracker, this is streamlined by eliminating the need for acquiring fiducial coordinates in both spaces (e.g., EM and CT space). The present embodiments eliminate the need for skin markers (fiducials) when the reference tracker is configured in accordance with the present principles, and its shape is manufactured to match its physical coordinates in EM space. The present embodiments overcome the shortcomings and practical constraints of fiducial-based registration systems.

It should be understood that the present embodiments are not limited to multi-modality registration but may also be employed for cross-modality calibration and other applications. In addition, although described for EM tracking, the present embodiments are not limited to this technology and other tracking mechanisms such as optical tracking may be employed.

It also should be understood that the present invention will be described in terms of medical instruments; however, the teachings of the present invention are much broader and are applicable to any instruments employed in tracking or analyzing complex biological or mechanical systems. In particular, the present principles are applicable to internal tracking procedures of biological systems, procedures in all areas of the body such as the lungs, gastrointestinal tract, excretory organs, blood vessels, etc. The elements depicted in the FIGS. may be implemented in various combinations of hardware and software and provide functions which may be combined in a single element or multiple elements.

The functions of the various elements shown in the FIGS. can be provided through the use of dedicated hardware as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions can be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which can be shared. Moreover, explicit use of the term “processor” or “controller” should not be construed to refer exclusively to hardware capable of executing software, and can implicitly include, without limitation, digital signal processor (“DSP”) hardware, read-only memory (“ROM”) for storing software, random access memory (“RAM”), non-volatile storage, etc.

Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass both structural and functional equivalents thereof. Additionally, it is intended that such equivalents include both

currently known equivalents as well as equivalents developed in the future (i.e., any elements developed that perform the same function, regardless of structure). Thus, for example, it will be appreciated by those skilled in the art that the block diagrams presented herein represent conceptual views of illustrative system components and/or circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams and the like represent various processes which may be substantially represented in computer readable storage media and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

Furthermore, embodiments of the present invention can take the form of a computer program product accessible from a computer-usable or computer-readable storage medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable storage medium can be any apparatus that may include, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk – read only memory (CD-ROM), compact disk – read/write (CD-R/W) and DVD.

Referring now to the drawings in which like numerals represent the same or similar elements and initially to FIG. 1A, a reference tracker 100 is shown disassembled in accordance with one illustrative embodiment. In one embodiment, the reference tracker 100 includes a

tracker portion 102 and a base portion or base 104. The tracker portion 102 has encoded therein x - y - z coordinate information into its geometry. The tracker portion 102 defines a coordinate system against which the sensors are measured to permit tracking of the medical device in EM tracking space.

The tracker portion 102 includes a connection feature 106. The connection feature 106 mates with a corresponding feature 108 on the base 104. The connection feature 106 and corresponding feature 108 may include a detent and a protrusion, a fin and groove, a key and keyhole, a pin and hole arrangement, a raised portion and a trench arrangement, etc. The connection feature 106 and corresponding feature 108 should be uniquely attached when engaged to so that that there is only one possible orientation of the base 104 with respect to the tracker portion 102. The base 104 and the encoded coordinate system of the tracker portion 102 coincide with each other.

The tracker portion 102 needs to be accurately calibrated so that a long axis that physically corresponds to the long edge of the base portion 104 demonstrates one axis (e.g., the y axis) in EM tracking space, and a short axis that physically corresponds to the short edge of the base portion 104 demonstrates a second axis (e.g., the x axis) in EM tracking space. A virtual third axis (e.g., z) can be easily computed from the other two axes. The base 104 may include a triangle shape with two edges converging at a right angle, or a cross or other geometric shape where at least two coordinate axes are defined. The base 104 uniquely connects with the tracker portion 102 to provide a visible indication for two defined axes. The orientation (or geometry) of the base 104 corresponds with the encoded axes manufactured into the tracker portion 102. FIG. 1B shows the tracker portion 102 and the base 104 assembled. In accordance with the present principles, a single reference tracker 100 may be employed for realizing multi-modality image fusion.

Referring to FIG. 2, in another embodiment, an integrated reference tracker 120 includes the base and tracker portion integrated into one piece, so that the geometry of the base corresponds with encoded directions of 3 axes of a local coordinate system fabricated into the tracker. The local coordinates of the reference tracker 120 are known and match with the shape of the reference tracker 120.

The reference trackers 100 or 120 may be employed to provide registration between real-time imaging (or tracking) and pre-operative imaging. In one embodiment, EM-CT registration is performed and becomes an easy process in accordance with the present principles.

The reference trackers 100, 120 may include different materials, suitable for different needs in different scenarios. The material selection should present a high contrast resolution and should be easily detectable in the requested image modality. For example, the base 104 or the outer material of reference tracker 120 may include some radio-opaque materials that are highly visible in CT images if the goal of the reference tracker is to realize EM-CT registration. Similarly other opaque materials may be employed for other imaging modalities.

Referring to FIG. 3, a system 200 for performing a medical procedure is illustratively depicted. System 200 may include a workstation or console 212 from which a procedure is supervised and managed. Workstation 212 preferably includes one or more processors 214 and memory 216 for storing programs and applications. Memory 216 may store a program or imaging module 215 configured to compute spatial transformations and register volumes between imaging system or between tracking and imaging systems. In one embodiment, module 215 may be configured to employ EM tracking data from an EM tracking system 225. The EM tracking system 225 tracks a position of a device 202 or instrument in a subject 230 during a procedure. The device 202 may include a catheter, a guidewire, a probe, an

endoscope, a robot or other device, etc.

Workstation 212 may include a display 218 for viewing internal images of the subject or patient 230 and may be employed for viewing registered images during the procedure. An imaging system or systems 210 may be employed. Imaging systems 210 may include a magnetic resonance imaging (MRI) system, a fluoroscopy system, a computed tomography (CT) system, etc. Display 218 may also permit a user to interact with the workstation 212 and its components and functions. This is further facilitated by an interface 220 which may include a keyboard, mouse, a joystick or any other peripheral or control to permit user interaction with the workstation 212.

The EM tracking system 225 may be integrated with the workstation 212 or be a separate system. The EM tracking system 225 connects to a field generator and control module 222 used to generate EM signals to locate sensors 224 on the device 202. The EM signals generated by the device 202 during a procedure are interpreted by the EM tracking system 225. The medical device 202 includes one or more EM tracking sensors 224, which may be mounted to the device 202. A field generator and control module 222 may include one or more coils or other magnetic field generation sources employed in tracking applications. A reference tracker 100 (or 120) includes a magnetically encoded orientation therein to represent coordinate axes. The encoding may employ magnetic field direction or the like to define the coordinate axes. The reference tracker 100 is fabricated or configured to indicate the coordinate system to the EM tracking system 225 to provide a reference coordinate system for the tracking operations of the procedure.

The EM tracking system 225 and the imaging system(s) 210 may be employed with module 215 to acquire and display internal images of a procedure or otherwise assist in tracking the activities of the procedure. The imaging module 215 may be part of the

individual imaging systems 210 or may be a separate module located in the workstation 212. The imaging module 215 coordinates imaging and tracking data from the various systems, computes transformations between different coordinate systems of the various systems and registers one coordinate system with another. The reference tracker 100 includes a shape (e.g., the base 104) to visually indicate the EM encoded coordinate system in the provided images.

Referring to FIG. 4, a side view or image 300 of a patient or subject 230 is illustratively shown. Prior to an image scan, the reference tracker 100 (or the reference tracker 120) is attached to a patient body (subject 230), and 3D images are collected with the base 104 visible therein. From the 3D images, legs 315, 317 of the base 104 are identified, so that 3D local coordinates 302 of the reference tracker 100 can be obtained. The 3D local coordinates 302 are precisely pre-calibrated during the manufacture of the reference tracker 100, which means that the x, y, z coordinates of the tracker portion 102 in physical space precisely encode x, y, z coordinates 302 in EM space. At this point, local coordinates 302 of EM reference tracker 100 are known in pre-operative imaging (e.g., CT) space coordinate system 304, since the base 104 is visible in scanned images. Thus, e.g., a EM-CT registration matrix can be easily computed by estimating a transformation matrix 310 between the EM reference tracker coordinates 302 and CT coordinates 304 that are centered on origin 312 (e.g., the DICOM origin).

During an interventional procedure, the tracker portion 102 is connected to the base 104 via the unique attachment mechanism (e.g., groove design, etc.), or in another embodiment, the tracker portion and the base are connected as one body (120). If an intra-operative imaging modality (such as an endoscope) is tracked using sensors (not shown), then we know where the endoscope is located relative to the reference tracker 100 or 120, and

thus to the CT origin 312. Other imaging coordinate systems 314 may be registered to the tracking system and/or to may be fused with other imaging modes using a single reference tracker 100 (or 120).

Pre-operatively, the geometry-enriched reference tracker 100, 120 can be used for EM-CT registration, EM-MRI registration, etc. This registration permits multi-modal intra-operative CT-endoscope fusion, MRI-ultrasound fusion, or fusing images between any number of other technologies or systems.

The reference tracker 100, 120 can be employed for calibrating intra-operative X-ray/Ultrasound space (which is usually 2D in nature) with EM tracking space. Without requiring an additional geometry-rich phantom, this calibration can be done by one single device, because the reference tracker 100, 120 encodes the tracking information into detectable geometry for each imaging platform being used.

In the example of X-ray/EM calibration, multiple X-ray views can be employed to reconstruct a 3D geometry of the reference tracker 100, 120. Thus, the x, y, z coordinates (from a reconstructed 3D view) of the reference tracker 100, 120 are mapped to the X-ray coordinate system, so that the EM-X-ray calibration matrix is acquired. If EM-MRI registration is in place, one can subsequently achieve X-ray-MRI registration as well. In particularly useful embodiments, the present principles can be applied in EM-CT registration which leads to CT-video registration; EM-MR registration which leads to MR-US registration; endoscope-EM calibration; X-ray-EM calibration; ultrasound-EM calibration, etc.

Referring to FIG. 5, a block/flow diagram shows a method for registering a tracking system with an image in accordance with one embodiment. In block 402, a reference tracker is provided in accordance with the present principles. The reference tracker includes a tracker

portion having a coordinate system encoded therein, e.g., using magnetic poles, etc., and a base portion associated with the tracker portion. The base portion has a geometry configured to coincide with at least two axes of the coordinate system. A third axis can be computed from the other two. The tracker portion and the base portion may be integrated in a single piece or may be separate pieces and include an attachment mechanism to uniquely couple the tracker portion and the base portion. The geometry of the base portion preferably includes a long side and a short side, the long side representing a first axis and the short side representing a second axis.

In block 404, the reference tracker is attached to a subject to define a tracking coordinate system using the encoding of tracking portion. In addition, the base portion defines a visible coordinate system for images, which corresponds exactly to the tracking coordinate system. The base portion preferably includes a material visible in the image to provide a visible indicator of the coordinate system in the image.

In block 408, the subject is imaged with the reference tracker visible in the image. In block 412, the coordinate system is registered to image space. In block 414, the registration of the tracking coordinate system with image space includes registering the coordinate system with at least one of pre-operative images and/or intra-operative images. In addition, multiple images from different imaging modalities may all be registered to the tracking coordinate system using the same method, in block 418. In block 420, multiple images may be fused together using the registered coordinate systems.

In block 422, the reference tracker defines the tracking coordinate system, and a medical instrument may be tracked during a procedure using the coordinate system. In block 424, the tracked medical instrument may have images registered for tracked positions in the image space during the procedure. In this way, the tracking system and the imaging system

may be employed to visually update images of a procedure in accordance with the medical instrument's position.

In interpreting the appended claims, it should be understood that:

- a) the word "comprising" does not exclude the presence of other elements or acts than those listed in a given claim;
- b) the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements;
- c) any reference signs in the claims do not limit their scope;
- d) several "means" may be represented by the same item or hardware or software implemented structure or function; and
- e) no specific sequence of acts is intended to be required unless specifically indicated.

Having described preferred embodiments for a device, system and method for multi-leg geometry reference tracker for multi-modality data fusion (which are intended to be illustrative and not limiting), it is noted that modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the disclosure disclosed which are within the scope of the embodiments disclosed herein as outlined by the appended claims. Having thus described the details and particularity required by the patent laws, what is claimed and desired protected by Letters Patent is set forth in the appended claims.

CLAIMS:

1. A reference tracker, comprising:
a tracker portion (102) having a coordinate system encoded therein against which a medical device is tracked; and
a base portion (104) associated with the tracker portion, the base portion having a geometry configured to coincide with at least two axes of the coordinate system to provide a visible indicator of the coordinate system in an anatomical image to permit registration between the anatomical image and the coordinate system.
2. The reference tracker as recited in claim 1, wherein the tracker portion and the base portion are integrated in a single piece (120).
3. The reference tracker as recited in claim 1, wherein the geometry of the base portion (104) includes a long side and a short side, the long side representing a first axis and the short side representing a second axis.
4. The reference tracker as recited in claim 1, wherein the base portion (104) includes a material that generates contrast in the image.
5. The reference tracker as recited in claim 1, wherein the tracker portion (102) includes a device for electromagnetic tracking.
6. The reference tracker as recited in claim 1, wherein the geometry of the base portion (104) includes one of a triangle shape, a cross shape or a rectilinear shape.

7. The reference tracker as recited in claim 1, wherein the tracker portion and the base portion are separate pieces and the geometry includes an attachment mechanism (106, 108) to uniquely couple the tracker portion and the base portion.

8. The reference tracker as recited in claim 7, wherein the attachment mechanism (106, 108) includes one of a raised portion and a trench arrangement.

9. A system, comprising:

a tracking system (225);

a reference tracker (100, 120) including:

a tracker portion (102) having a coordinate system encoded therein, the coordinate system defining coordinate for the tracking system; and

a base portion (104) associated with the tracker portion, the base portion having a geometry configured to coincide with at least two axes of the coordinate system and formed from a material to provide a visible indicator of the coordinate system in an anatomical image to permit registration between the anatomical image and the coordinate system; and

an imaging system (210) configured to generate the anatomical image.

10. The system as recited in claim 9, wherein the tracker portion and the base portion are integrated in a single piece (120).

11. The system as recited in claim 9, wherein the geometry of the base portion (104) includes a long side and a short side, the long side representing a first axis and the short

side representing a second axis.

12. The system as recited in claim 9, wherein the geometry of the base portion (104) includes one of a triangle shape, a cross shape or a rectilinear shape.

13. The system as recited in claim 9, wherein the imaging system (210) includes at least one of a magnetic resonance imaging system, an ultrasonic imaging system, a computed tomography imaging system, or a fluoroscopy imaging system.

14. The system as recited in claim 9, wherein the anatomical image (300) includes a plurality of anatomical images and the reference tracker permits fusion of the plurality of anatomical images using the coordinate system.

15. The system as recited in claim 9, further comprising at least one sensor (224) coupled to an interventional medical instrument, the interventional medical instrument being tracked by the tracking system during a procedure using the coordinate system.

16. The system as recited in claim 9, wherein the tracker portion and the base portion are separate pieces and the geometry includes an attachment mechanism (106, 108) to uniquely couple the tracker portion and the base portion.

17. The system as recited in claim 16, wherein the attachment mechanism (106, 108) includes one of a raised portion and a trench arrangement.

18. A method for registering a tracking system with an image, comprising:
providing (402) a reference tracker including a tracker portion having a coordinate system encoded therein, and a base portion associated with the tracker portion, the base portion having a geometry configured to coincide with at least two axes of the coordinate system;

attaching (404) the reference tracker to a subject;

imaging (408) the subject with the reference tracker visible in the image; and

registering (412) the coordinate system with image space of the image.

19. The method as recited in claim 18, wherein registering the coordinate system with image space includes registering (414) the coordinate system with at least one of pre-operative images or intra-operative images.

20. The method as recited in claim 18, wherein the reference tracker defines the coordinate system employed by a tracker system, and further comprising tracking (422) a medical instrument during a procedure using the coordinate system.

21. The method as recited in claim 20, wherein tracking the medical instrument during the procedure includes registering (424) tracked positions with the image space.

22. The method as recited in claim 18, wherein the base portion (104) includes a material visible in the image to provide a visible indicator of the coordinate system the image.

23. The method as recited in claim 18, wherein the tracker portion and the base

portion are integrated in a single piece (120).

24. The method as recited in claim 18, wherein the geometry of the base portion includes a long side and a short side, the long side representing a first axis and the short side representing a second axis.

25. The method as recited in claim 18, wherein the tracker portion and the base portion are separate pieces and the geometry includes an attachment mechanism (106, 108) to uniquely couple the tracker portion and the base portion.

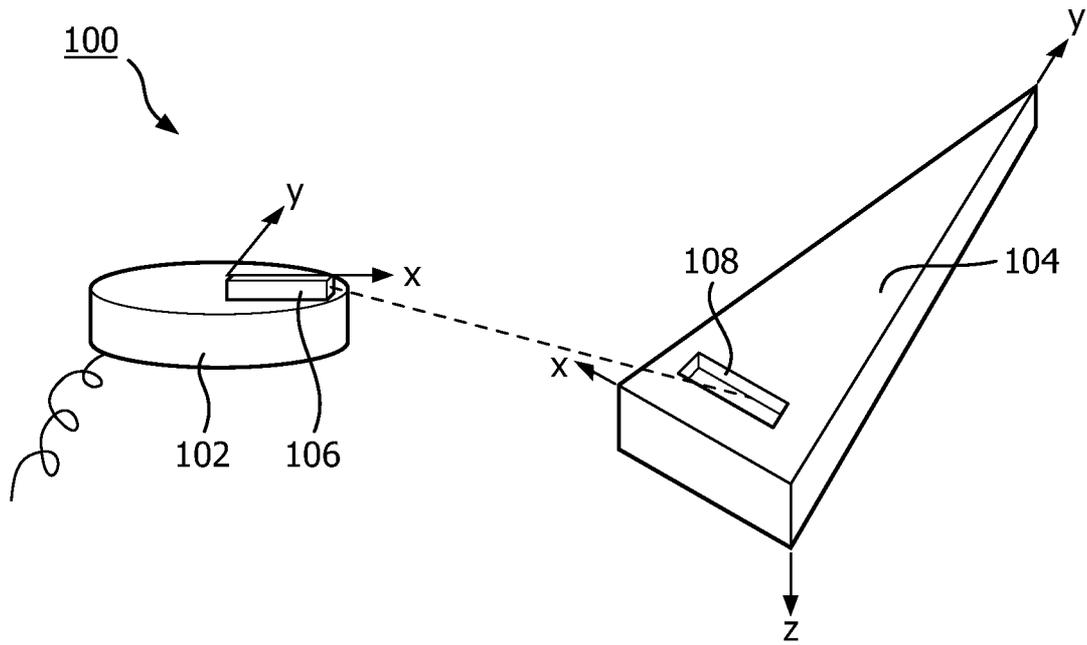


FIG. 1A

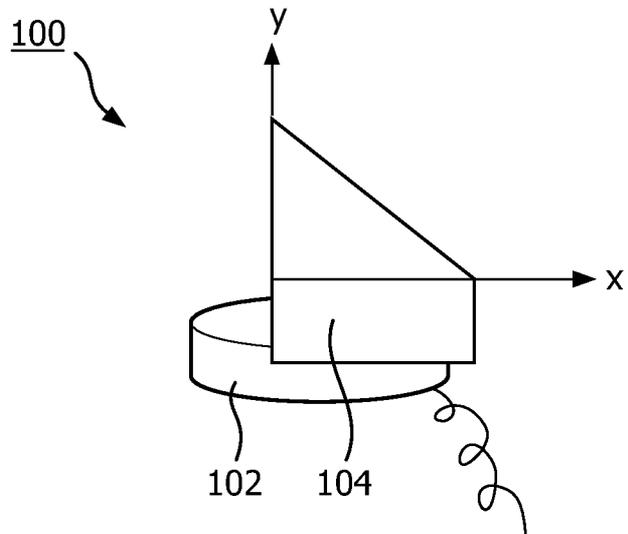


FIG. 1B

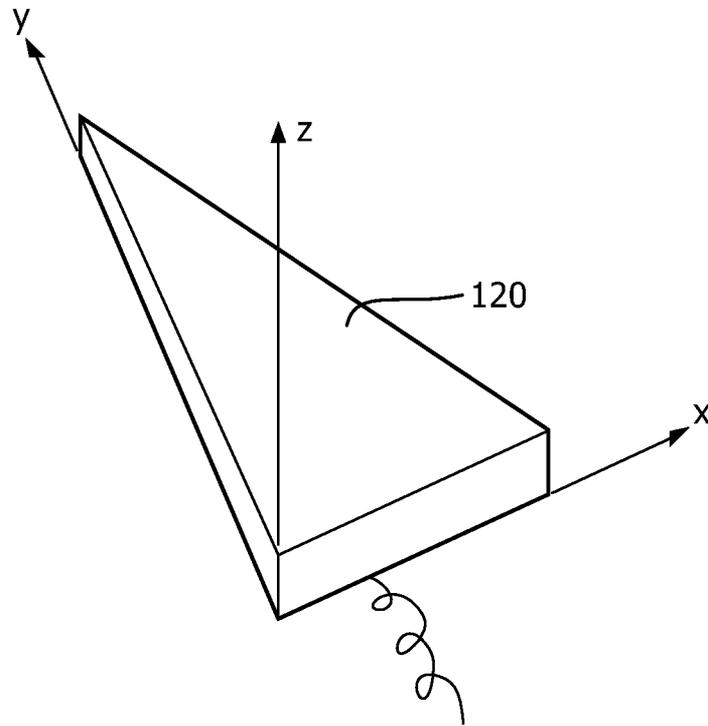


FIG. 2

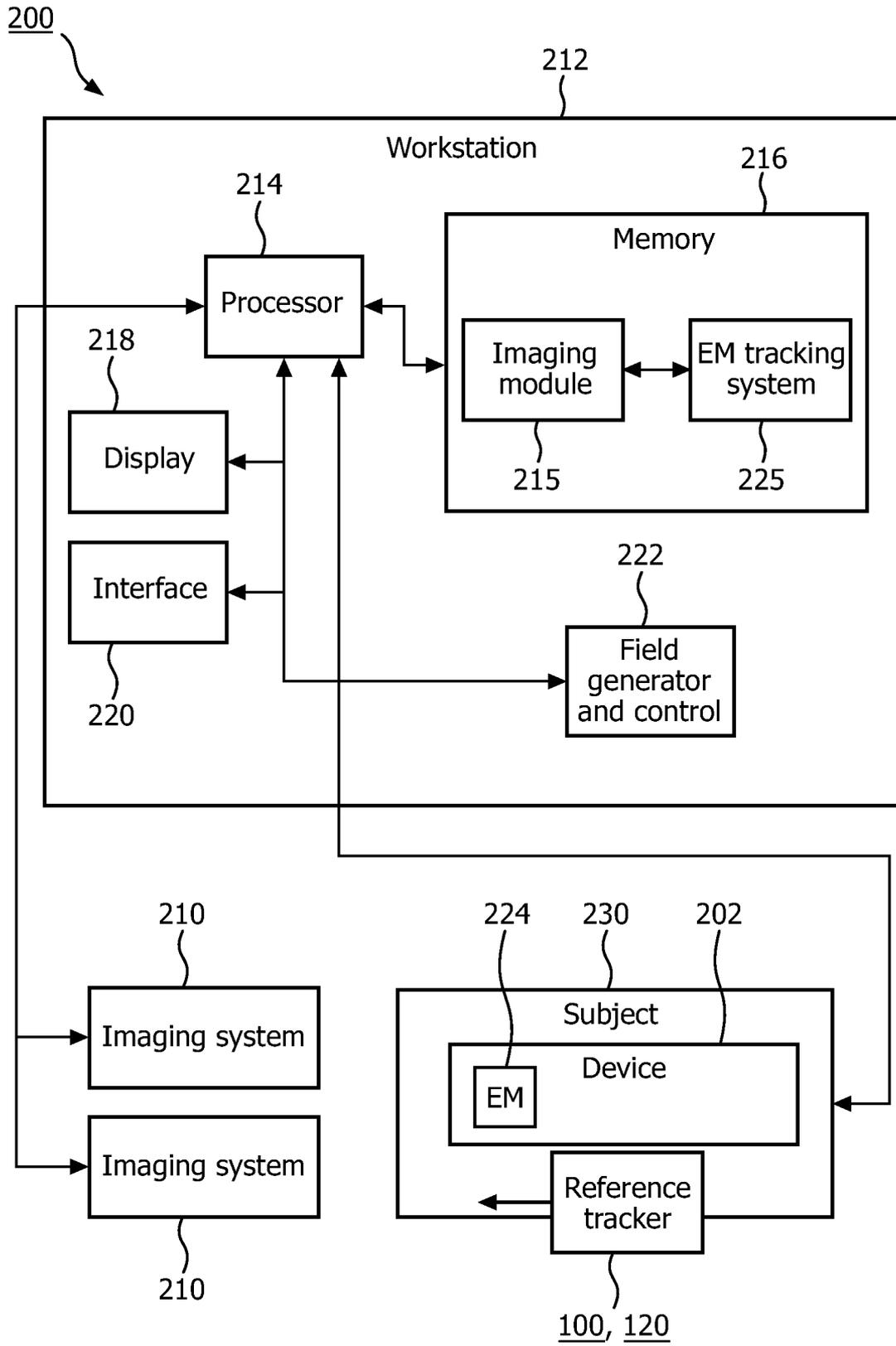
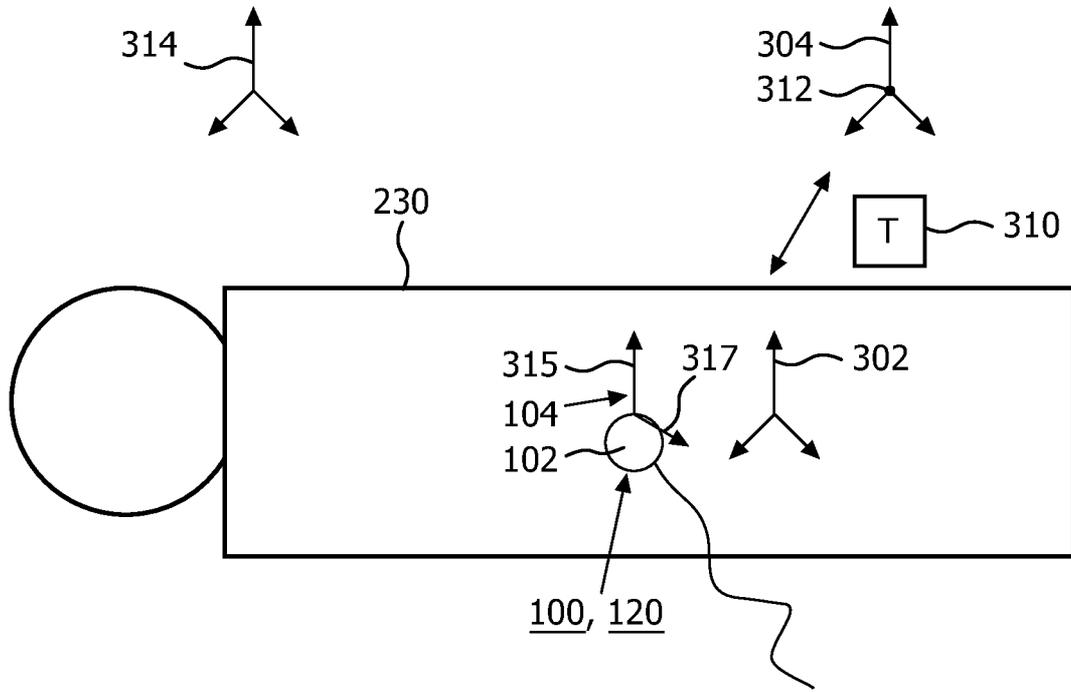


FIG. 3



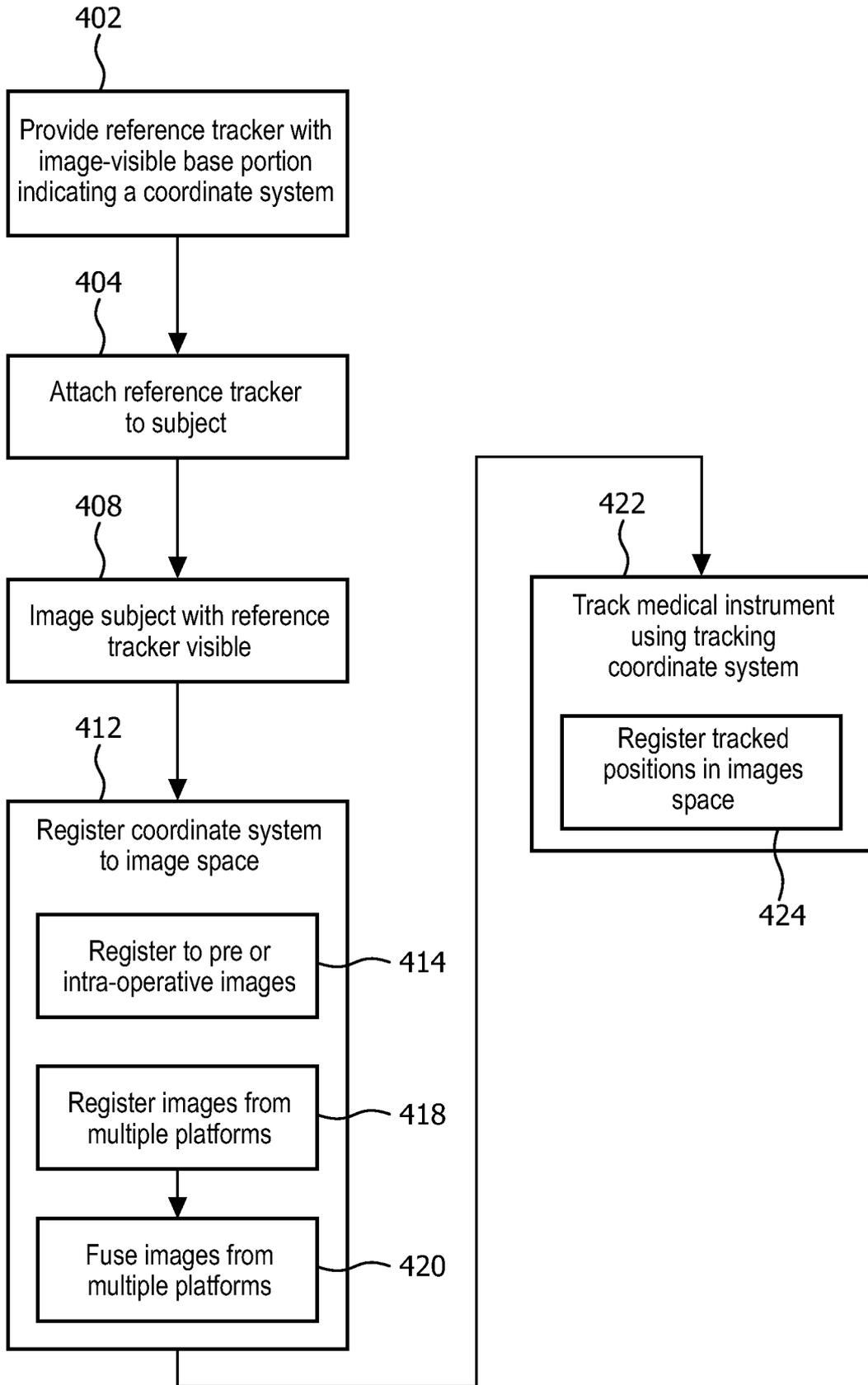


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/051146

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B19/00
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

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/086374 A1 (IMACTIS [FR]; LAVALLEE STEPHANE [FR]; CARRAT LIONEL [FR]) 5 August 2010 (2010-08-05) the whole document	1-25
X	WO 2010/145975 A1 (SIEMENS AG [DE]; BULITTA CLEMENS [DE]; GRAUMANN RAINER [DE]) 23 December 2010 (2010-12-23) the whole document	1-25
X	WO 01/34050 A2 (MEDTRONIC SURGICAL NAVIGATION [US]) 17 May 2001 (2001-05-17) page 11, paragraph 3; figure 3 page 14 - page 16	1-12, 14-17

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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