

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

(19) World Intellectual Property Organization

International Bureau



(10) International Publication Number

WO 2013/156893 A1

(43) International Publication Date  
24 October 2013 (24.10.2013)

WIPO | PCT

(51) International Patent Classification:  
*A61B 1/00* (2006.01)      *A61B 19/00* (2006.01)

KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(21) International Application Number:  
PCT/IB2013/052797

(22) International Filing Date:  
8 April 2013 (08.04.2013)

(25) Filing Language:  
English

(26) Publication Language:  
English

(30) Priority Data:  
61/635,327      19 April 2012 (19.04.2012)      US

(71) Applicant: KONINKLIJKE PHILIPS N.V. [NL/NL];  
High Tech Campus 5, NL-5656 AE Eindhoven (NL).

(72) Inventors: POPOVIC, Aleksandra; c/o High Tech Campus, Building 5, NL-5656 AE Eindhoven (NL). EL-HAWARY, Haytham; c/o High Tech Campus, Building 5, NL-5656 AE Eindhoven (NL).

(74) Agents: STEFFEN, Thomas et al.; High Tech Campus Building 5, NL-5656 AE Eindhoven (NL).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

#### Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- 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))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: GUIDANCE TOOLS TO MANUALLY STEER ENDOSCOPE USING PRE-OPERATIVE AND INTRA-OPERATIVE 3D IMAGES

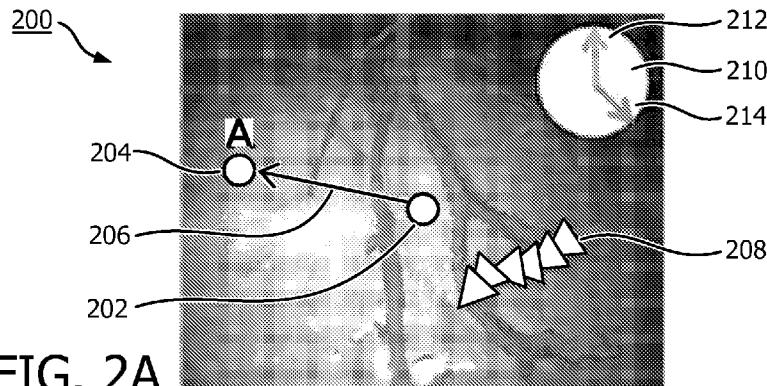


FIG. 2A

(57) Abstract: Systems and methods for guided endoscope navigation include a registration module (118) configured to, using a processor, register a first set of images (112) with a second set of images (114) of an endoscope (102). A selection module (120) is configured to receive selected areas of interest on the first set of images and transform the selected areas of interest to an endoscope coordinate frame. A guidance module (122) is configured to overlay guidance tools onto the second set of images to permit a user of the endoscope to navigate to the selected areas of interest.

WO 2013/156893 A1

## GUIDANCE TOOLS TO MANUALLY STEER ENDOSCOPE USING PRE-OPERATIVE AND INTRA-OPERATIVE 3D IMAGES

5 This disclosure relates to medical instruments and more particularly to guidance tools for manually steering endoscopes.

Coronary artery bypass grafting (CABG) is a surgical procedure for the revascularization of obstructed coronary arteries. Minimally invasive CABG is performed using an endoscope as the only feedback from the operating site. In a standard setup for a 10 minimally invasive CABG procedure, a surgeon uses both hands to hold instruments while an assistant holds the endoscope. The endoscope is typically inserted into the chest cavity from the right side of the patient or from the posterior-anterior direction. This may result in three relevant coordinate systems: the coordinate system of the endoscope (e.g., camera), the coordinate system of the surgeon, and the coordinate system of the assistant. This can lead to 15 a number of problems. For instance, while the surgeon is looking forward at the screen, the camera is representing the anatomy from a side view. In addition, if the camera located on the top of the endoscope were to be rotated 180°, the image would appear inverted on the screen. However, there is currently no way of knowing the camera's orientation. Moreover, the 20 assistant has to respond to instructions from the surgeon as to how to move the endoscope. An order such as "right" may correspond to moving the endoscope left and down, which may be highly counter-intuitive for the assistant and may lead to a trial and error approach. These problems may lead to prolonged operating room time and inefficiencies in the workflow.

In accordance with the present principles, novel solutions for guidance tools for 25 manually steering an endoscope are provided. In one embodiment, the present principles may include registering preoperative and/or intraoperative images with images of an endoscope.

Visual cues may be overlaid onto the endoscope view as guidance tools to permit a user to navigate the endoscope towards selected areas of interest. The motion of the endoscope may be tracked in real-time using image features to update the visual cues. In another embodiment, the present principles may pre-orient a camera of an endoscope such that the

5 coordinate system of the camera corresponds with a preferred coordinate system of the user. The camera of the endoscope may be mounted on an actuated platform, which pre-orient the endoscope by rotating the camera to correspond to a preferred direction of the user. Advantageously, the present principles provide for efficient steering to manually navigate an endoscope. This may lead to reduced operating room time and a more efficient workflow.

10 A system for guided endoscope navigation includes a registration module configured to, using a processor, register a first set of images with a second set of images of an endoscope. A selection module is configured to receive selected areas of interest on the first set of images and transform the selected areas of interest to an endoscope coordinate frame. A guidance module is configured to overlay guidance tools onto the second set of images to permit a user of the endoscope to navigate to the selected areas of interest.

15

A system for guided endoscope navigation includes a registration module configured to, using a processor, register a first set of images with a second set of images of an endoscope. A selection module is configured to receive selected areas of interest on the first set of images and transform the selected areas of interest to an endoscope coordinate frame.

20 A guidance module is configured to overlay guidance tools onto the second set of images. An actuation module is configured to orient a camera of the endoscope such that a coordinate system of the camera corresponds with a coordinate system of the user to permit a user of the endoscope to navigate to the selected areas of interest.

A method for guided endoscope navigation includes registering, using a processor, a

first set of images with a second set of images of an endoscope. Areas of interest are selected on the first set of images and the selected areas of interest are transformed to an endoscope coordinate frame. Guidance tools are overlaid onto the second set of images to permit a user of the endoscope to navigate to the selected areas of interest.

5 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:

10 FIG. 1 is a block/flow diagram showing a system for manually steering an endoscope using guidance tools, in accordance with one embodiment;

FIG. 2A is an illustrative example of an endoscope image with overlaid direction, path and directional error indicator, in accordance with one embodiment;

15 FIG. 2B is an illustrative example of an endoscope image with an overlaid distance error indicator displaying distance, in accordance with one embodiment;

FIG. 2C is an illustrative example of an endoscope image with an overlaid distance error indicator using a virtual spring, in accordance with one embodiment;

20 FIG. 3A is a block/flow diagram showing a system for orienting an endoscope camera's coordinate system with an endoscope user's coordinate system, in accordance with one embodiment;

FIG. 3B is an illustrative example of an endoscope image to orient an endoscope camera's coordinate system with an endoscope user's coordinate system, in accordance with one embodiment; and

FIG. 4 is a block/flow diagram showing a method for manually steering an endoscope

using guidance tools, in accordance with one embodiment.

In accordance with the present principles, embodiments for a system, apparatus and method provide guidance tools for manually steering an endoscope. In one embodiment, preoperative and/or intraoperative images are registered with images of an endoscope. Visual cues may be overlaid onto the endoscope view as guidance tools to permit a user (e.g., surgeon assistant) to steer the endoscope towards selected areas of interest. The motion of the endoscope may be tracked in real-time using image features to update the visual cues. Visual cues may include, but are not limited to: a direction indicator showing the direction to the selected areas of interest, an endoscope tracer showing the motion of the endoscope, a directional error indicator showing the angular error of the motion of the endoscope compared to the direction to the selected areas of interest, a distance error indicator showing distance to the selected areas of interest, and anatomical reference directions showing anatomical directions. Other visual cues are possible and have been contemplated within the scope of the present principles.

In another embodiment, the present principles may pre-orient an endoscope camera's coordinate system with a user's preferred coordinate system. In order to pre-orient the camera in a preferred direction, the camera of the endoscope may be mounted on an actuated platform. The endoscope user moves the endoscope in the physical direction in which he or she would prefer to correspond to the, e.g., "upwards" direction in the image. The angle between the physical movement of the endoscope and the actual upwards direction in the image is determined and the actuated platform rotates the camera accordingly to pre-orient the coordinate frames. It is noted that the present principles are not limited to the upwards direction, but may include any direction.

It should be understood that the present invention will be described in terms of an

endoscope; however, the teachings of the present invention are much broader and are applicable to any optical scope that can be employed in internal viewing of branching, curved, coiled or other shaped systems. In some embodiments, the present principles are employed in tracking or analyzing complex biological or mechanical systems (e.g., digestive systems,

5 circulatory systems, piping systems, passages, mines, caverns, etc.). 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, gastro-intestinal 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 10 multiple elements. Embodiments described herein are preferably displayed for viewing on a display monitor. Such monitors may include any suitable display device including but not limited to handheld displays (e.g., on personal digital assistants, telephone devices, etc.), computer displays, televisions, designated monitors, etc. Depending of the scope, the display may be provided as part of the system or may be a separate unit or device.

15 It should also be understood that the optical scopes may include a plurality of different devices connected to or associated with the scope. Such devices may include a light, a cutting device, a brush, a vacuum, a camera, etc. These components may be formed integrally with a head on a distal end portion of the scope. The optical scopes may include a camera disposed at a tip of the scope or a camera may be disposed at the end of an optical cable opposite the 20 tip.

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 10 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 15 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-readable or computer-readable storage medium providing program code for use by or in connection with a computer or any instruction 20 execution system. For the purposes of this description, a computer-readable 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 –

5 read/write (CD-R/W), Blu-Ray™ and DVD.

Referring now to the drawings in which like numerals represent the same or similar elements and initially to FIG. 1, a system 100 for manually steering an endoscope using guidance tools is illustratively depicted in accordance with one embodiment. System 100 may include a workstation or console 108 from which procedures (e.g., endoscopy) are supervised and managed. Workstation 108 preferably includes one or more processors 138 and memory 110 for storing programs and applications. It should be understood that the functions and components of system 100 may be integrated into one or more workstations or systems.

10 10

Memory 110 may store images 112. Images 112 may include preoperative images and intraoperative images, which may be received from systems including, but not limited to, a magnetic resonance imaging (MRI) system, a computed tomography (CT) system, an x-ray system, a 3-D ultrasound system, etc. Memory 110 may also store scope images 114 received from scope 102. In a preferred embodiment, scope 102 is an endoscope to capture intraoperative images of the operation site from camera 106. Scope images 114 may preferably include video from camera 106 of endoscope 102.

15 20

The present principles may be applied for different applications of endoscopically-guided minimally invasive surgery. For example, the present principles may be used for cardiac surgery (e.g., minimally invasive coronary artery bypass grafting, atrial septal defect closure, valve repair/replacement, etc.), laparoscopic surgery (e.g., hysterectomy, prostatectomy, gall bladder surgery, etc.), natural orifice transluminal surgery,

pulmonary/bronchoscopy surgery, neurosurgical interventions, and videos assisted thoracic surgery. However, it is noted that the teachings of the present principles are much broader than this, as scope 102 may include any type of scope for various types of applications. In one exemplary embodiment, the present principles may be applied to manually navigate a 5 plumber's snake through piping. Other applications are also contemplated.

Workstation 108 may include one or more displays 134 for viewing preoperative and intraoperative images 112 and scope images 114 including guidance features of the present principles. The display 134 may also permit a user to interact with workstation 108 and its components and functions. This is further facilitated by a user interface 136, which may 10 include a keyboard, mouse, joystick, or any other peripheral or control to permit user interaction with workstation 108.

A computer implemented program 116 is stored in memory 110 of workstation 108. The program 116 may include a number of modules, each configured to perform various functions. It should be understood that the modules may be implemented in various 15 combinations of hardware and software.

Program 116 may include registration module 118, which is configured to perform registration between images 112 (e.g., preoperative images and/or intraoperative images) and scope (e.g., endoscope) images 114. Registration is performed as is known in the art.

Program 116 may also include selection module 120, which is configured to allow a 20 user (e.g., a surgeon) to select areas of interest on the preoperative and intraoperative images 112 (e.g., CT or x-ray). For example, a selected area of interest may be a target bypass artery in a coronary artery bypass grafting procedure. Selection module 120 may include the use of display 134 and user interface 136 to facilitate this selection. Selection module 120 then transforms the selected areas of interest from the preoperative and/or intraoperative image

coordinate frame to the endoscope coordinate frame using the registration transformation determined in registration module 118.

Program 116 may include guidance module 122, which is configured to use the selected areas of interest in the endoscope view to determine a number of guidance indicators.

5 Guidance module 122 may include, but is not limited to, any or all of direction module 124, path module 126 and distance module 128. Other indicators have also been contemplated.

Direction module 124 determines a direction from the current center of the endoscope image to the selected areas of interest to overlay a directional indicator onto the endoscope image. Referring for a moment to FIG. 2A, an endoscope image including overlaid indicators 10 200 is illustratively depicted, in accordance with one embodiment. A directional indicator 206 is overlaid on an endoscope image to show the direction from the center of the endoscope image 202 to the selected areas of interest 204.

Guidance module 122 of FIG. 1 may include path module 126 to further aid the user (e.g., a surgeon or an assistant) in navigating the endoscope. Referring back for a moment to 15 FIG. 2 A, an endoscope trace 208 is overlaid onto an endoscope image to show the motion of the endoscope. The trace 208 is generated by tracking the position of one or more anatomical features that are located at the center of the endoscope image and overlaying an arrow to mark that location on the endoscope image. At each frame or period of frames, the current feature in the center of the image is overlaid with an arrow on the endoscope image, while 20 continuing to track the features previously at the center of the image. Continuing this process, a visual trail may be created to help a user steering an endoscope to navigate to the selected areas of interest 204.

The direction of trace 208 may be compared to the direction of the target area of interest 204 to display an angular error using visual cues. In one embodiment, a dial 210 can

be displayed using hands 212 and 214 to indicate the angular offset between the motion of the endoscope 208 and the direction of the selected areas of interest 206, respectively. Other visual cues indicating the angular error are also contemplated. For example, an angle (e.g., in degrees) between direction to selected areas of interest 206 and motion of the endoscope 208 5 can be displayed.

Guidance module 122 may also include distance module 128, which is configured to indicate the distance from the center of the endoscope image to the target areas of interest. Referring for a moment to FIG. 2B, an endoscope image with an overlaid distance error indicator 220 is illustratively depicted in accordance with one embodiment. The endoscope 10 image may include directional indicator 206 showing the direction from the center of the endoscope image 202 to target area of interest 204. In one embodiment, a distance 222 (e.g., in pixels) can be indicated as a number on the screen. In another embodiment, a line between the center of the endoscope image 202 and the selected areas of interest 204 can be represented as a function of distance. For example, referring for a moment to FIG. 2C, an 15 endoscope image with an overlaid distance indicator using a virtual spring 240 is illustratively depicted in accordance with one embodiment. A virtual spring 242 joins the center of the endoscope image 202 with the selected areas of interest 204. The virtual spring may appear stretched as the distance between the two points grows further apart and compressed as the distance becomes closer. Other distance error indicators have also been contemplated. For 20 example, the color of the line between the center of the endoscope image 202 and the selected areas of interest 204 can change with distance, with a legend displayed on the screen to define the colors. In another embodiment, the thickness of the line can be modified as distance changes.

In yet another embodiment of the present principles, direction module 124 of FIG. 1

may overlay anatomical reference directions onto the endoscope image. As preoperative and intraoperative images 112 are registered with endoscope images 114 by registration module 118, the anatomical reference directions of the preoperative and intraoperative images are determined. The anatomical reference directions are transformed into the endoscope 5 coordinate system and overlaid onto the endoscope image. Anatomical reference directions may include, but are not limited to, anterior/posterior, left/right and head/foot directions. Other anatomical directions are also contemplated.

Using the overlaid guidance indicators of guidance module 122, a user navigates the endoscope 102. The endoscope motion is traced, as discussed above, to determine if 10 endoscope 102 has reached the selected areas of interest. The operations of the guidance module 122 are repeated until the selected areas of interest are reached. Once the selected area of interest is reached, the process ends.

In one embodiment of the present principles, program 116 of FIG. 1 may also include actuation module 130 to further aid the user in navigating the endoscope 102. Actuation 15 module 130 is configured to pre-orient camera 106 using actuated platform 104 such that a coordinate system of the camera corresponds with a preferred coordinate system of the user. Actuation module 130 receives the direction a user prefers to correspond to the, e.g., upwards direction. For example, a user may physically move the endoscope in the preferred upwards direction. The angle between the physical motion of the endoscope and the true upwards 20 direction of the endoscope image is computed and passed as an input to the actuated platform, which pre-orientates the camera accordingly. It is noted that the corresponding direction is not limited to the upwards direction, but rather may include any direction.

Referring now to FIG. 3A, a system for orienting an endoscope camera's coordinate system with an endoscope user's coordinate system 300 is illustratively depicted in accordance

with one embodiment. Camera 106 is mounted on actuated platform 104 on scope 102. Actuated platform 104 rotates according to the received angle to orient the camera accordingly. Referring for a moment for FIG. 3B, an illustrative example of an endoscope image with overlaid orienting indicators 320 is shown in accordance with one embodiment. A 5 user moves the endoscope in a preferred upwards direction, resulting in motion of endoscope 324 from center of image indicator 202. The angle between motion of the endoscope 324 and the true upwards direction of the image 322 is computed to determine angle 326, which is passed to actuated platform 104 to orient the camera accordingly.

Referring now to FIG. 4, a method for manually steering an endoscope using guidance 10 tools 400 is illustratively depicted in accordance with one embodiment. In block 402, scope images are registered with preoperative and/or intraoperative images. Scope images are preferably images of an endoscope including a camera to capture intraoperative images of the operation site. Endoscope images may preferably include video. Preoperative and/or intraoperative images may be received from systems including, but not limited to, an MRI 15 system, a CT system, an x-ray system, a 3D ultrasound system, etc. Registration is performed as is known in the art.

In block 404, areas of interest may be selected on the preoperative and intraoperative images. In block 406, the selected areas of interest may be transformed from the preoperative and intraoperative images coordinate frame to the endoscope image coordinate frame. This 20 may include use of the registration transformation determined in block 402.

In block 408, the direction from the current center of the endoscope image to the selected areas of interest is determined in the endoscope image. Using this direction, in block 410, guidance indicators are overlaid onto the endoscope image. Guidance indicators may include, for example, but are not limited to, a directional indicator, an endoscope tracer, a

directional error indicator, a distance error indicator, and anatomical reference direction indicator. Other guidance indicators are also contemplated.

In one embodiment, guidance indicators may include a directional indicator overlaid onto the endoscope image to show the direction from the current center of the endoscope image to the selected areas of interest. In another embodiment, an endoscope trace may be overlaid onto the endoscope image showing the endoscope motion. The trace may be generated by tracking the position of each anatomical feature that is located at the center of the endoscope image and overlaying an arrow to mark that location on the endoscope image. At each frame or period of frames, the current feature in the center of the image is overlaid with an arrow on the endoscope image, while continuing to track the features previously at the center of the image. Continuing this process, the positions of each of the features are displayed in the endoscope image to provide a visual trail that can help a user navigate the endoscope.

In yet another embodiment, the endoscope trace may be compared to the direction of the selected areas of interest to determine an angular error, representing the angular offset between the motion of the endoscope and the direction to the selected areas of interest. The angular error may be overlaid onto the endoscope image using visual cues. In an embodiment, a dial including two hands is overlaid onto the endoscope image, where each hand indicates the trace of the endoscope and direction to the selected areas of interest, respectively. In another example, angular error may be indicated by displaying the angle (e.g., in degrees) on the endoscope image.

In one embodiment, guidance indicators may include a distance error indicator overlaid onto the endoscope image. As the endoscope is moved, the distance from the center of the endoscope image to the selected areas of interest will vary. A distance error can be overlaid

onto the endoscope images to help the user navigate the endoscope. For example, the distance (e.g., in pixels) can be indicated as a number of the screen. In another example, the line that joins the center of the endoscope image and the selected areas of interest can be represented as a function of distance. This may include representing the line as a virtual 5 spring, which may appear stretched as the distance gets larger and compressed as the distance gets smaller. Alternatively, the color or thickness of the line may change according to distance. Other representations of distance error are also contemplated.

In another embodiment, anatomical reference directions may be overlaid onto the endoscope images. As preoperative and intraoperative images are registered (block 402), the 10 anatomical reference directions of the preoperative and intraoperative images are determined and transformed into the endoscope view. Anatomical reference directions may include, for example, anterior/posterior, left/right and head/foot directions. Other anatomical reference directions are also contemplated.

In block 414, using the guidance indicators overlaid onto the endoscope image, a user 15 can navigate the endoscope with increased efficiency. The endoscope motion is tracked to determine if the selection area of interest is reached. In block 416, if the selected area of interest is not reached, steps 408, 410, 414 and 416 are repeated until the selected area of interest is reached in block 418. Advantageously, the present principles aid a user to navigate an endoscope efficiently, resulting in reduced operating room time.

20 In one embodiment of the present invention, in block 412, a camera of the endoscope can be pre-oriented such that a coordinate system of the camera corresponds with a preferred coordinate system of the user. A user can indicate a preferred, e.g., upwards direction. This may include a user physically moving the endoscope in the preferred upwards direction. The angle between the physical motion of the endoscope and the actual upwards direction of the

endoscope image is computed and passed as an input to an actuated platform mounted between the camera and endoscope. The actuated platform rotates the camera according to the received angle to aid the user in navigating the endoscope. It is noted that the corresponding direction is not limited to the upwards direction, but rather may include any

5 direction.

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
- 10 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

15 indicated.

Having described preferred embodiments for guidance tools to manually steer endoscope using pre-operative and intra-operative 3D images (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

20 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 guidance system for endoscope navigation, comprising:  
a registration module (118) configured to, using a processor, register a first set of  
images (112) with a second set of images (114) of an endoscope (102);  
5 a selection module (120) configured to receive selected areas of interest on the first set  
of images and transform the selected areas of interest to an endoscope coordinate frame; and  
a guidance module (122) configured to overlay guidance tools onto the second set of  
images to permit a user of the endoscope to navigate to the selected areas of interest.

10 2. The system as recited in claim 1, further comprising:  
an actuation module (130) configured to orient a camera (106) of the endoscope such  
that a coordinate system of the camera corresponds with a coordinate system of the user.

15 3. The system as recited in claim 2, wherein the actuation module (130) is further  
configured to rotate an actuation platform including the camera in accordance with an angle  
between a first direction and an actual direction of the first direction.

20 4. The system as recited in claim 1, wherein the guidance module (122) includes a  
direction module (124) configured to overlay a direction indicator (206) onto the second set  
of images, the direction indicator being from a center of a frame of the second set of images  
(202) to the selected areas of interest (204).

5. The system as recited in claim 1, wherein the guidance module (122) includes a  
path module (126) configured to overlay a path (208) of a motion of the endoscope onto the

second set of images.

6. The system as recited in claim 5, wherein the path (208) is generated by tracking positions of anatomical features including at least one of anatomical features located at a center of a frame of the second set of images and anatomical features previously located at the center of the frame.

5 7. The system as recited in claim 4, wherein the direction module (124) is further configured to overlay an angular error indicator (210) onto the second set of images to show 10 an angular error between the direction indicator (206) and a path (208) of a motion of the endoscope.

15 8. The system as recited in claim 1, wherein the guidance module (122) includes a distance module (128) configured to overlay a distance indicator (222) onto the second set of images indicating a distance from a center of a frame of the second set of images (202) to the selected areas of interest (204).

9. The system as recited in claim 8, wherein the distance indicator (222) is a line (242) from the center of the frame to the selected areas of interest that varies as a function of 20 distance.

10. The system as recited in claim 9, wherein the line is a virtual spring (242) that appears compressed as the distance decreases and stretched as the distance increases.

11. The system as recited in claim 9, wherein a color of the line varies as a function of distance.

12. The system as recited in claim 1, wherein the guidance module (122) includes a 5 direction module (124) configured to overlay anatomical directions of the first set of images onto the second set of images.

13. A guidance system for endoscope navigation, comprising:  
a registration module (118) configured to, using a processor, register a first set of 10 images (112) with a second set of images (114) of an endoscope (102);  
a selection module (120) configured to receive selected areas of interest on the first set of images and transform the selected areas of interest to an endoscope coordinate frame;  
a guidance module (122) configured to overlay guidance tools onto the second set of images; and  
15 an actuation module (130) configured to orient a camera (106) of the endoscope such that a coordinate system of the camera corresponds with a coordinate system of the user to permit a user of the endoscope to navigate to the selected areas of interest.

14. The system as recited in claim 13, wherein the actuation module (130) is further 20 configured to rotate an actuation platform including the camera in accordance with an angle between a first direction and an actual direction of the first direction.

15. A method for guided endoscope navigation, comprising:  
registering (402), using a processor, a first set of images with a second set of images

of an endoscope;

selecting (404) areas of interest on the first set of images and transforming (406) the selected areas of interest to an endoscope coordinate frame; and

overlying (410) guidance tools onto the second set of images to permit a user of the

5 endoscope to navigate to the selected areas of interest.

16. The method as recited in claim 15, further comprising:

orienting (412) a camera of the endoscope such that a coordinate system of the camera corresponds with a coordinate system of the user.

10

17. The method as recited in claim 16, wherein orienting (412) includes rotating an actuation platform including the camera in accordance with an angle between a first direction and an actual direction of the first direction.

15

18. The method as recited in claim 15, wherein overlying (410) includes overlying a direction indicator onto the second set of images, the direction indicator being from a center of a frame of the second set of images to the selected areas of interest.

20

19. The method as recited in claim 15, wherein overlying (410) includes overlying a path of a motion of the endoscope onto the second set of images.

20. The method as recited in claim 19, wherein the path is generated by tracking positions of anatomical features including at least one of anatomical features located at a center of a frame of the second set of images and anatomical features previously located at the

center of the frame.

21. The method as recited in claim 18, wherein overlying (410) includes overlying an angular error indicator onto the second set of images to show an angular error between the 5 direction indicator and a path of a motion of the endoscope.

22. The method as recited in claim 15, wherein overlying (410) includes overlying a distance indicator onto the second set of images indicating a distance from a center of a frame of the second set of images to the selected areas of interest.

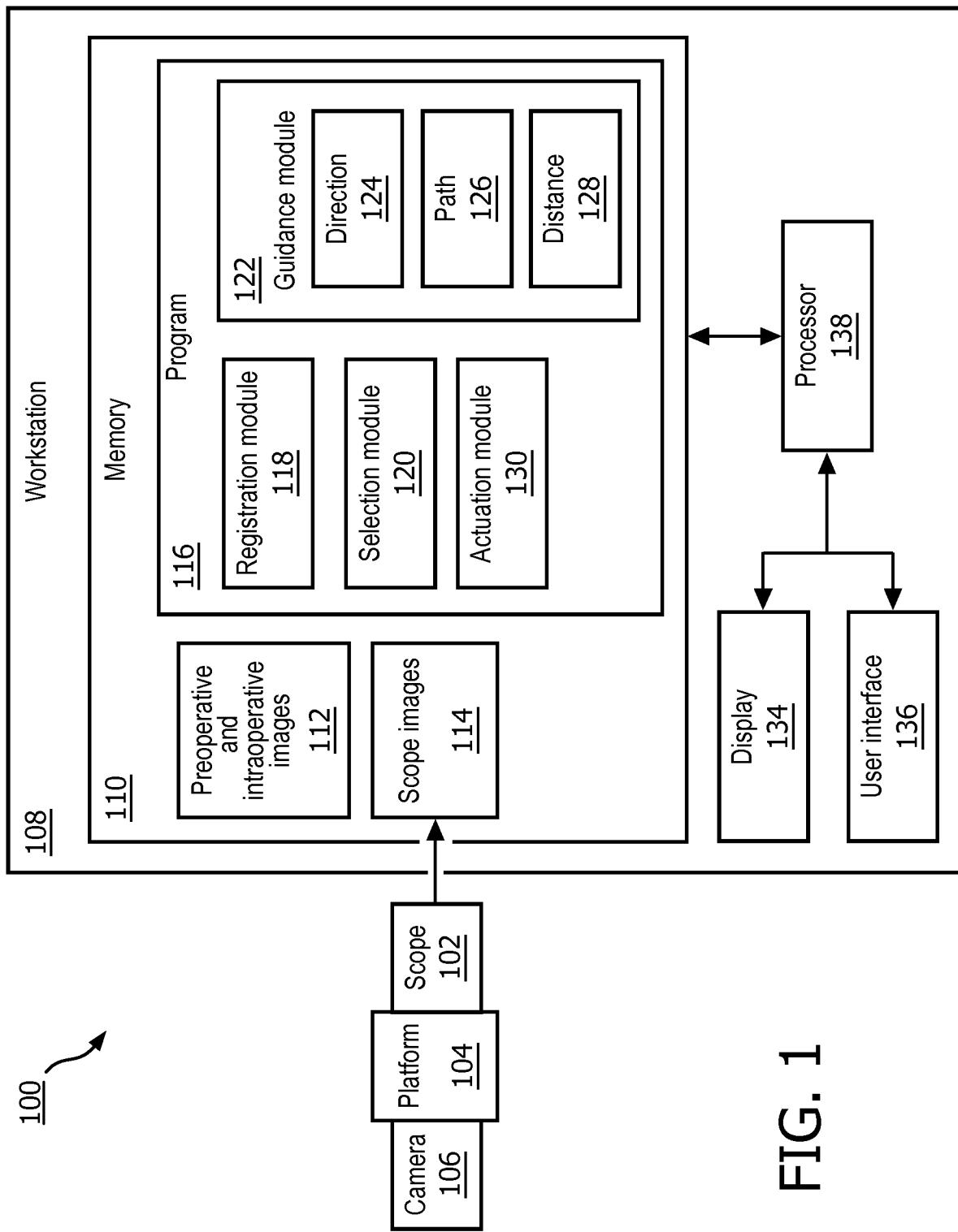
10

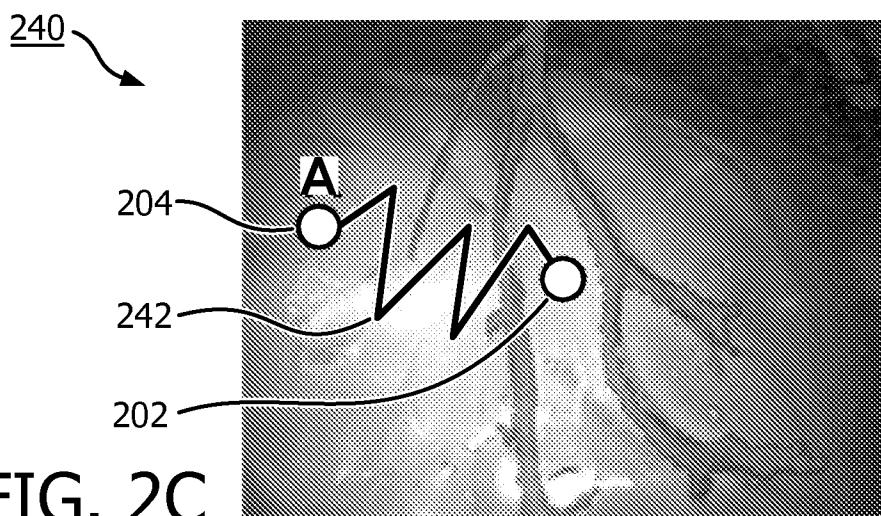
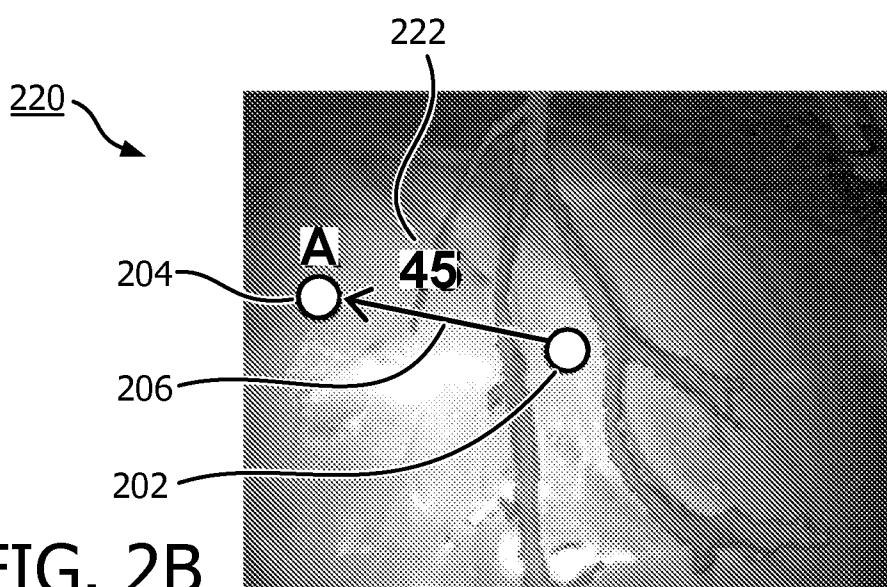
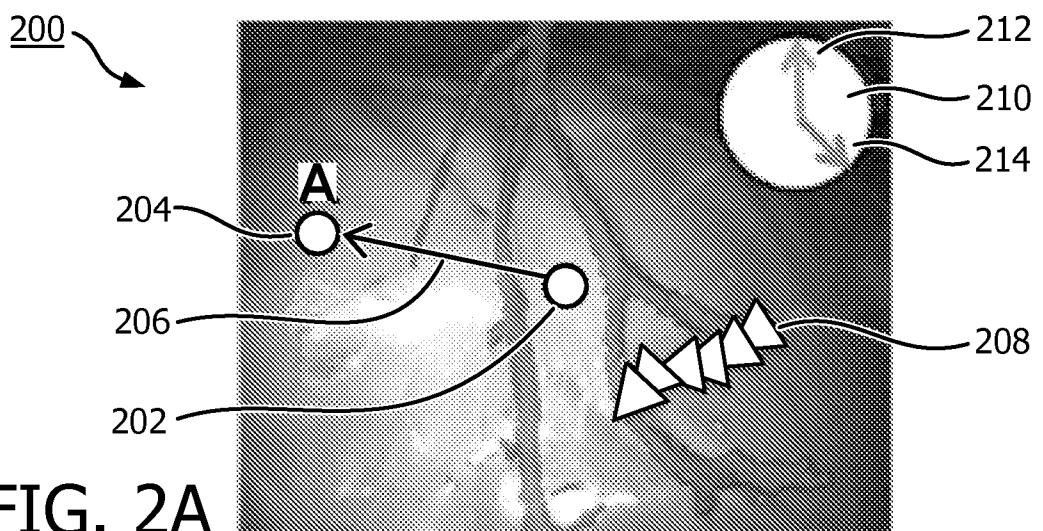
23. The method as recited in claim 22, wherein the distance indicator is a line from the center of the frame to the selected areas of interest that varies as a function of distance.

24. The method as recited in claim 23, wherein the line is a virtual spring that appears 15 compressed as the distance decreases and stretched as the distance increases.

25. The method as recited in claim 23, wherein a color of the line varies as a function of distance.

20 26. The method as recited in claim 15, wherein overlying (410) includes overlying anatomical directions of the first set of images onto the second set of images.

**FIG. 1**



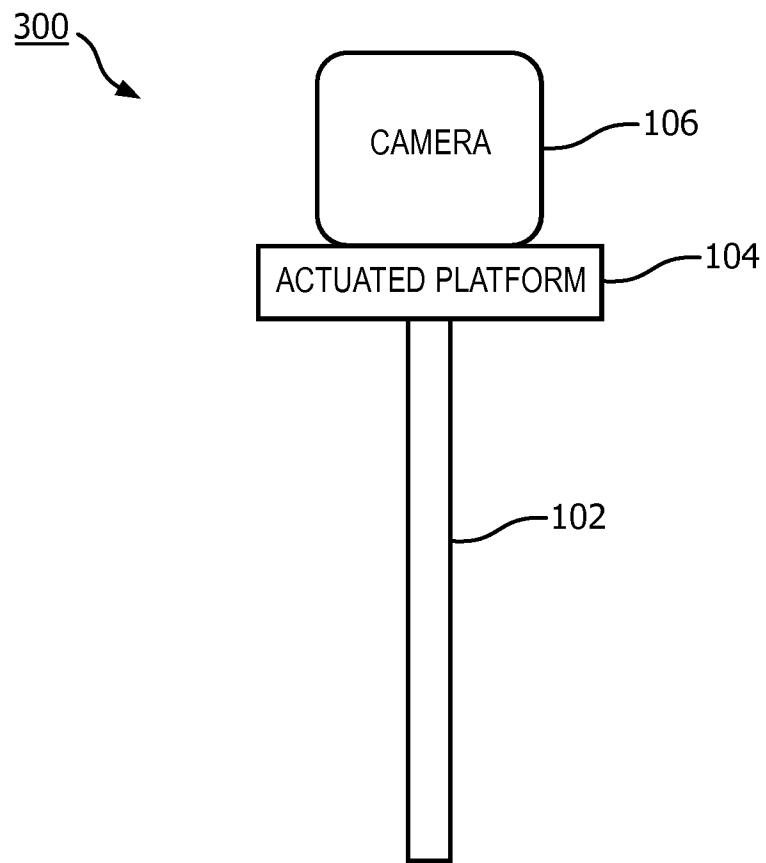


FIG. 3A

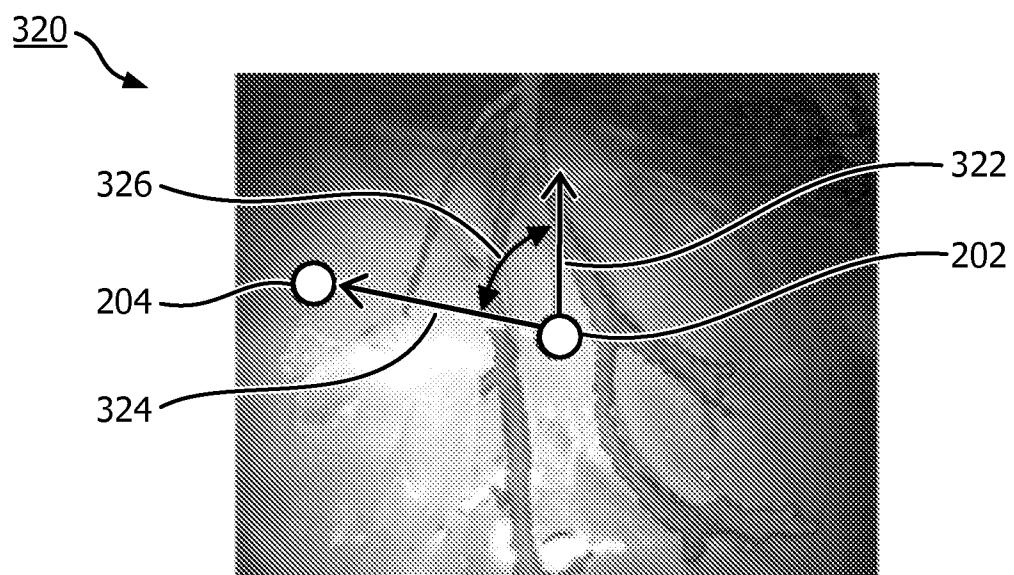


FIG. 3B

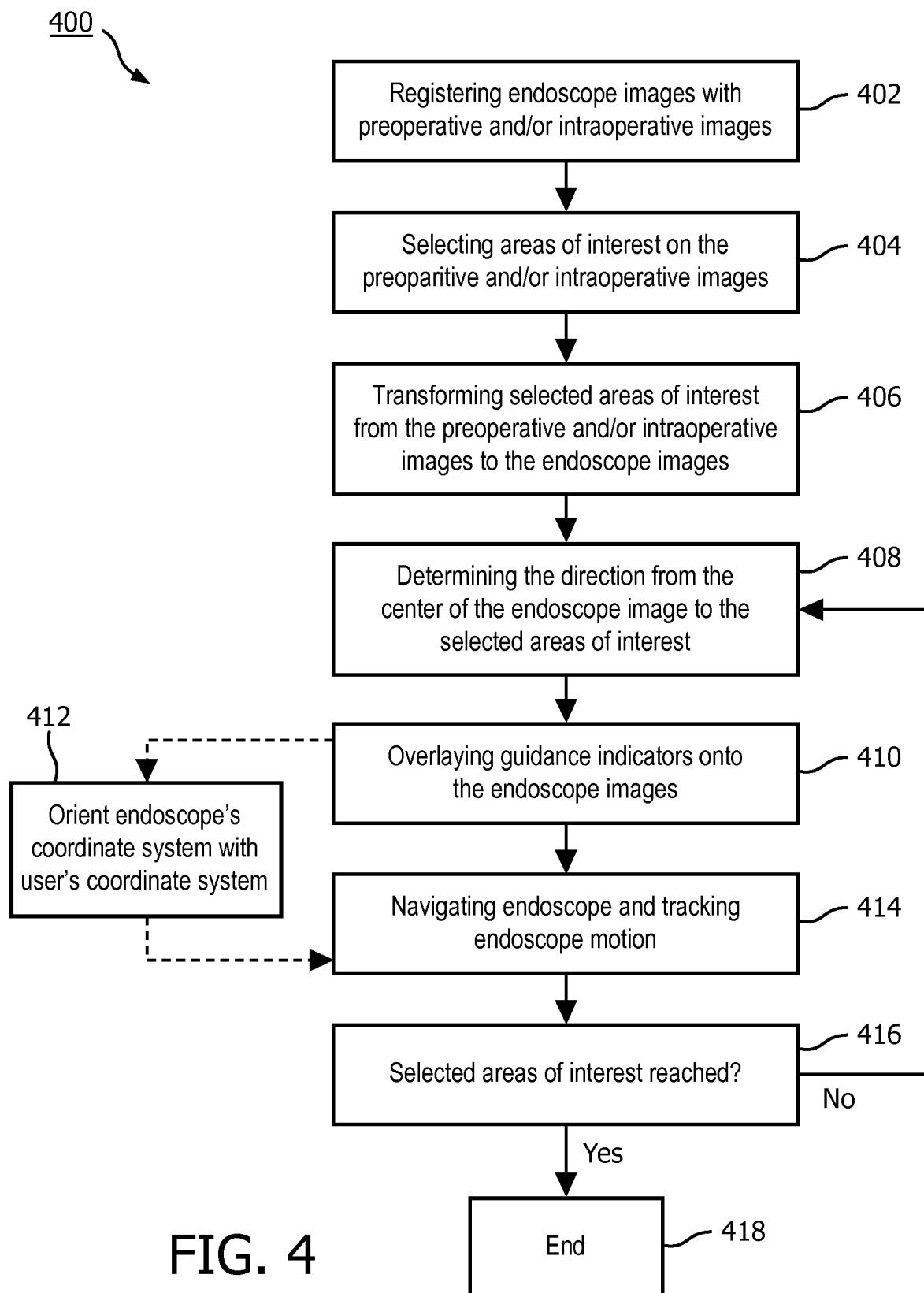


FIG. 4

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2013/052797

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61B1/00 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 2010/111090 A1 (INTUITIVE SURGICAL OPERATIONS [US]) 30 September 2010 (2010-09-30) figures 3,15 paragraphs [0037], [0064] - [0068], [0072] -----	1-4,8,9, 11-14
X	US 2008/287783 A1 (ANDERSON PETER T [US]) 20 November 2008 (2008-11-20) figures 1-5 -----	1,4,5,7
X	US 2008/262297 A1 (GILBOA PINHAS [IL] ET AL) 23 October 2008 (2008-10-23) figures 1-6 -----	1,4,5,8
X	US 2002/077544 A1 (SHAHIDI RAMIN [US]) 20 June 2002 (2002-06-20) figures 1-5 -----	1,4,8
		-/-

Further documents are listed in the continuation of Box C.

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  26 September 2013	Date of mailing of the international search report  08/10/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Schießl, Werner

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2013/052797

## C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/036162 A1 (SHAHIDI RAMIN [US] ET AL) 16 February 2006 (2006-02-16) figures 10,12-14 paragraph [0039] ----- US 2006/004286 A1 (CHANG JOHN Y [US] ET AL) 5 January 2006 (2006-01-05) paragraphs [0110], [0116] - [0118]; figures 10A,11B,11C,12 -----	1,4,8
X		1,5,12

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IB2013/052797

### Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.: **15-26**  
because they relate to subject matter not required to be searched by this Authority, namely:  
**Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery since a method for guided endoscopic navigation encompasses movement of an endoscope within a living body.**
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

#### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2013/052797
---

Patent document cited in search report	Publication date	Patent family member(s)			Publication date
WO 2010111090	A1	30-09-2010	CN	102449666 A	09-05-2012
			EP	2411966 A1	01-02-2012
			KR	20120014242 A	16-02-2012
			WO	2010111090 A1	30-09-2010
-----					
US 2008287783	A1	20-11-2008	NONE		
-----					
US 2008262297	A1	23-10-2008	EP	1761160 A2	14-03-2007
			EP	2316328 A1	04-05-2011
			US	2008262297 A1	23-10-2008
			WO	2005102175 A2	03-11-2005
-----					
US 2002077544	A1	20-06-2002	AU	9283601 A	02-04-2002
			EP	1365686 A2	03-12-2003
			JP	2004513684 A	13-05-2004
			US	2002077544 A1	20-06-2002
			WO	0224051 A2	28-03-2002
-----					
US 2006036162	A1	16-02-2006	NONE		
-----					
US 2006004286	A1	05-01-2006	EP	1879499 A2	23-01-2008
			US	2006004286 A1	05-01-2006
			WO	2006116597 A2	02-11-2006
-----					