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

CORRECTED VERSION

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
5 June 2008 (05.06.2008)

PCT

(10) **International Publication Number**
WO 2008/066944 A3

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

(21) **International Application Number:** PCT/US2007/067357

(22) **International Filing Date:** 25 April 2007 (25.04.2007)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
11/410,578 25 April 2006 (25.04.2006) US

(71) **Applicant and**
(72) **Inventor: SHAHINIAN, Hrayr, Karnig** [US/US]; 8635 W.Third Street, Suite 1170W, Los Angeles, CA 90048 (US).

(74) **Agent: HALAJIAN, Dicran;** Thome & Halajian, LLP, 111 West Main Street, Bay Shore, NY 11706 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, **BR,** BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, 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, 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, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, **DK,** EE, ES, FI, FR, GB, GR, HU, IE, **IS, IT,** LT, LU, LV, MC, MT, NL, PL, PT, **RO,** SE, **SI,** SK, TR), OAPI (BF, **BJ,** CF, CG, CI, CM, GA, GN, GQ, GW, ML, **MR,** NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report*

(88) **Date of publication of the international search report:** 28 August 2008

(48) **Date of publication of this corrected version:** 25 September 2008

(15) **Information about Correction:**
see Notice of 25 September 2008

(54) **Title:** REMOTE MANIPULATOR WITH EYEBALLS

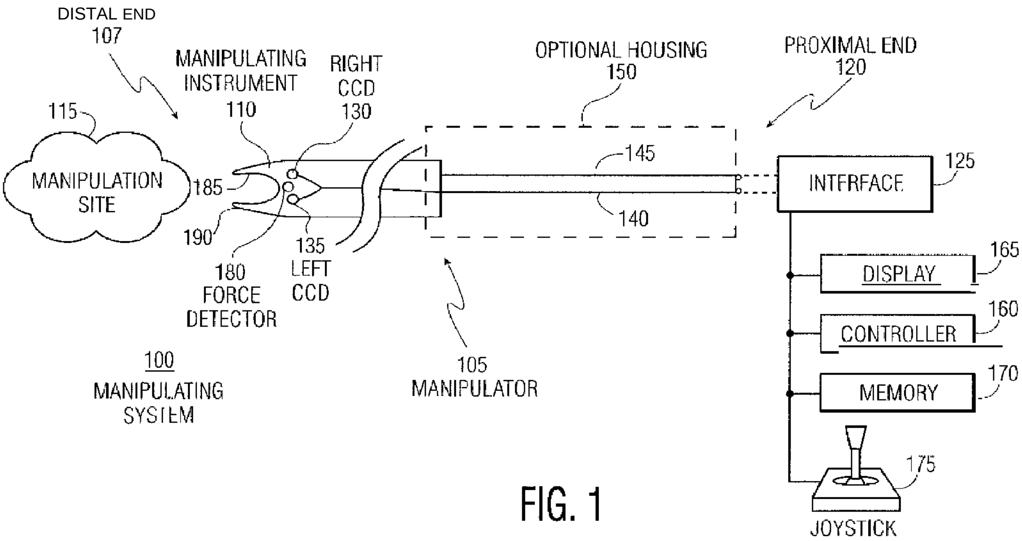

FIG. 1

(57) **Abstract:** A manipulator (105) includes a distal end (107) having a manipulating instrument (110) configured for manipulation at a manipulation site, and a proximate end (120) connectable to an interface (125). A pair of detectors (130,135) is configured to capture stereoscopic images of the manipulation site. The pair of detectors (130, 135) and manipulating instrument (110) are connected to the interface (125) by at least a flexible guide (140) and a wired and/or wireless communication link. The detectors are co-locatable at the manipulation site with the manipulating instrument and may be removable attached to manipulating instrument. A force detector (180) may also be removable attached to manipulating instrument.

WO 2008/066944 A3

REMOTE MANIPULATOR WITH EYEBALLS

The present invention relates generally to a method and system having at least one manipulator with eyeballs for providing stereoscopic vision of a remote manipulation site.

Remote manipulating, such as using robots, is becoming more prevalent, particularly for difficult to reach manipulation and/or observation sites, such as remote and/or tight spaces, or for handling potentially hazardous material including chemicals, radioactive, explosive and infectious material, etc. Even if the material being handled or manipulated is not potentially hazardous, remote manipulation is important for manipulating sites, whether or not such sites are easily accessible directly. Space exploration, medical surgery and mining operations are some examples of such manipulation and/or observation sites, which may also include other sites.

One system which is used in endoscopy or minimally invasive medicine, referred to as the Hopkins rod lens system, illuminates and thus facilitates endoscopic diagnosis and removal of foreign bodies inside a patient, where an endoscope is inserted either through natural body openings or small incisions. The interior of the body may be viewed through the scope. The Hopkins rod lens system includes a wide-angle lens at the distal end of the endoscope, and an eyepiece at the proximal end for viewing distal images. A fiberscope is provided inside the endoscope. The fiberscope has a flexible fiber optic bundle that interconnects the distal lens and the proximal eyepiece. The eyepiece may be connected to a camera. Typically, an additional fiber optic is also provided inside the endoscope for directing light from a light source outside the body, i.e., from the proximal end, to illuminate the distal end for clearer viewing. All fiberscopes introduce a certain amount of image distortion similar to the distortion of modern night vision equipment.

To enhance remote manipulation, cameras are used to provide visual images of the manipulation sites. Advances lead to the use of two cameras to provide stereoscoping images of the manipulation sites where right and left cameras provide different images to the right and left eye, simultaneously or alternately, where the different images may also be projected onto a display device or screen, for viewing through glasses or goggles worn by the manipulator.

Typically, the cameras are provided on a holding instrument or a housing which is separate from the manipulating instrument. For example, in medical applications, cameras may be provided alongside an endoscope, or on the endoscope through which (or alongside of the endoscope) a manipulating instrument is inserted. The manipulating instrument may include a laser or ultrasound source for performing minimally invasive surgery, detectors and sensors to measure internal body characteristics, or other devices, such as balloons configured to be inflated in the manipulation site, such as vessels, to provide for insertion of other instruments or to maintain the vessel diameter and prevent vessel collapsing, for example. Endoscopy equipment is produced by imaging companies such as Stryker Corporation, Fujinon, PENTAX, Olympus and Karl Storz.

Telesurgery using robotic systems allows a surgeon to operate from a site remote from the patient. The first transatlantic surgery is referred to as the Lindbergh Operation. Pill-sized endoscopic capsules have also been used with a camera, referred to as capsule cameras. For example, lcm x 2cm endoscopic capsules can capture 0.4 megapixel video at up to 30 frames/second. Physicians may even be provided with rotational control over the capsule to adjust the camera direction, take tissue samples and deliver medications to the patient's body.

Capsule cameras, endoscopic capsules or video pills are being promoted as alternatives to endoscopy. However capsules cannot be navigated and controlled precisely and thus cannot be used for operations requiring precision, such as brain or eye surgery and the like. Capsule cameras are primarily used to visualize the small intestine. Whereas the upper gastrointestinal tract (esophagus, stomach, and duodenum) and the colon (large intestine) can be adequately visualized with scopes having cameras placed at the proximal end of a thin flexible tube. The capsule camera can wirelessly transmit two images every second to a receiver carried by the patient. The main uses today are for detecting the cause of gastrointestinal bleeding, and for inflammatory bowel disease, such as Crohn's disease. Currently, capsule cameras do not provide stereoscopic images.

The following publications and patents provide examples of prior art devices having cameras to provide stereoscopic images, for example. All of these publications and patents are incorporated by reference as if set out in their entirety herein:

U.S. Patent No. 5,751,341 to Chaleki, entitled "Stereoscopic Endoscope System;"

U.S. Patent Application Publication No. 2005/0065658 to Green, entitled "Flexible Robotic Surgery System and Method;"

U.S. Patent Application Publication No. 2005/0065657 to Green, entitled "Computed pivotal center surgical robotic system and method;"

U.S. Patent No. 6,73 1,988 to Green, entitled "System and Method for Remote Endoscopic Surgery;"

U.S. Patent No. 6,223,100 to Green, entitled "Apparatus and Method for Performing Computer Enhanced Surgery with Articulated Instrument;"

WO 96/35975 to White, entitled "Device and Method for Superimposing Images in a Three-Dimensional Setting without Using Lenses;"

FR 02847995 A l to Trousset, entitled "Procede of Treatment of Information of Order Transmitted by a Peripherique of Handling of Images of Modelisation 3D, and Installation for the Visualization of Medical Images in Room of Intervention and/or Examination;"

U.S. Patent No. 6,290,649 to Miller, entitled "Ultrasound Position Sensing Probe;"

U.S. Patent No. 6,21 1,848 to Plesniak, entitled "Dynamic Holographic Video with Haptic Interaction;"

U.S. Patent No. 6,046,727 to Rosenberg, entitled "Three Dimensional Position Sensing Interface with Force Output;"

U.S. Patent Application Publication No. 2006/0055773 to Kutka, entitled "Device and method for stereoscopic reproduction of picture information on a screen;"

U.S. Patent Application Publication Nos. 2006/0038880 and 2006/0038881 to Starkweather, entitled "Stereoscopic image display;"

U.S. Patent Application Publication No. 2006/0036383 to Clare, entitled "Method and device for obtaining a stereoscopic signal;"

U.S. Patent Application Publication No. 2006/0012753 to Gandara, entitled "Stereoscopic imaging;"

U.S. Patent Application Publication No. 2006/0012674 to Kao, entitled "Image display system and method;"

U.S. Patent Application Publication No. 2006/0082644 to Tsubaki, entitled "Image processing apparatus and image processing program for multi-viewpoint image;" and

U.S. Patent Application Publication No. 2006/0080878 to Kittrell, entitled "Three-dimensional display frame assembly."

There is a need to provide for smaller manipulator systems having three-dimensional (3-D) and/or stereoscopic vision that can be precisely controlled for accurate manipulation and visualization of a manipulation site being manipulated with a manipulator of the manipulator systems.

According to one embodiment of the system, a manipulator includes a distal end having a manipulating instrument configured for being manipulated at a manipulation site, and a proximate end connectable to an interface. A pair of detectors at the distal end is configured to capture stereoscopic images of the manipulation site. The pair of detectors and manipulating instrument are connected to the interface, by at least a flexible guide and a wired and/or wireless communication link. The detectors are co-locatable at the manipulation site with the manipulating instrument and may be removably attached to the manipulating instrument. Other detectors may also be removably and/or fixedly attached to manipulating instrument, such as force detector(s) to provide tactile or haptic feedback, and environment measuring detector(s) to determine various aspects of the manipulation site, such as distinguish between healthy and abnormal tissue in medical applications. Any of the detectors may be fixedly or removably attached to its own guide or connecting line instead of being fixedly or removably attached to the distal end of the manipulator 105 or to the manipulating instrument.

Of course, in addition to, or instead of, being connected to the interface, the proximate end may simply be configured for manual manipulation by the operator, for example, to guide the manipulating instrument and perform desired operations by hand. The manipulating instrument, the pair of detectors, one detector, and/or multiple detectors may be attached to the flexible guide. Upon guidance to the desired position, the flexible guide may be rendered rigid to hold the manipulating instrument and/or detector(s) in the desired position.

According to another embodiment, a method of remotely manipulating a manipulation site includes the acts of:

providing a manipulating instrument at the manipulation site;

providing a pair of detectors on the manipulating instrument, the pair of detectors being removably attached to the manipulating instrument; and

controlling the pair of detectors to capture stereoscopic images of the manipulation site.

These and other features, aspects, and advantages of the apparatus and methods of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

FIG 1 shows an illustrative embodiment of a remote manipulator system according to the present system; and

FIGs 2-5 show various embodiment of manipulator instruments and detectors of the remote manipulator system according to the present system.

The present system will be explained below in the context of an illustrative implementation related to medical applications. However, it is to be understood that the present invention is not limited to a particular application or structural embodiment. Rather, the invention is more generally applicable to any manipulator for manipulating any remote manipulation site related to any suitable application such as space exploration, medical surgery, mining operations, inspection of equipment, where it is desirable to improve remote manipulation, examination and vision of manipulation sites, such as sites with small tightly packed components (in an equipment, a biological body, or otherwise) that are not easily accessible. Other applications and uses of the manipulator include machining, computer repair, clandestine monitoring, locksmithing, safecracking, and computer forensics, rescue operations in collapsed structures, etc.

Referring now to FIG 1, there is shown an illustrative embodiment of a manipulator system 100 having a manipulator 105. The manipulator 105 includes an interface device 125 at its proximal end 120, as wells as a manipulating instrument 110 and a pair of detectors 130, 135 at its distal end 107. The interface device 125, the manipulating instrument 110 and the pair of detectors 130, 135, as well as other elements of the manipulator system 100, individually or collectively may be part of, or integrated with, the manipulator 105, or may be fixedly or removably attachable to the manipulator 105 or to further flexible guides. For example, the detectors 130, 135 may be integrated with a controllable moving mechanism to form a detection system that may be clipped, snapped, screwed or otherwise removably attached to the manipulating instrument 110, or to its own flexible guide, e.g., via Velcro type of mechanism, small magnets having low magnetic fields that do not provide noticeable interference or the like.

The controllable moving mechanism may provide pan/tilt/zoom function for moving the detectors 130, 135 in unison for 3-D imaging, or moving each detector independently for 2-D imaging if needed, such as in tights spaces or around corners with room for only one of the detectors.

The manipulating instrument 110 may be any kind of instrument configured to manipulate or monitor any suitable manipulation site 115. Illustratively, the manipulating instrument 110 is a medical instrument used in minimally invasive surgery, where it is inserted into a patient through a small incision site or natural body opening, and is directed to a desired location or manipulation site 115 for performing a medical operation including diagnosis, be it probing and taking measurements of bodily functions and tissue type, e.g., to identify tissue type and/or distinguish between normal and abnormal tissue, or removing of unwanted tissue, such as through cutting, heating, cooling or pulverizing through any suitable means such as using razors, lasers, ultrasound or cryogenic devices.

Any type of sensor and/or manipulating instrument may be attached, e.g., fixedly or removably attached, to the distal end 107 of the manipulator 105. It should be understood that any of the detectors, or group thereof, may be attached to its own guide or connecting line instead of being attached to the distal end 107 of the manipulator 105 or to the manipulating instrument 110.

Illustratively, sensors alone or with the manipulating instrument 110 may be attached to the distal end 107, including sensors configured to take measurements for differentiating between normal tissue and abnormal tissue or tumors, for example, substantially at or near the manipulation site 115. Sensors may be provided in addition to or instead of the manipulating instrument 110 to measure and not only differentiate between normal and abnormal tissue or tumors, but also to determine tissue and/or tumor characteristics, such as type, size etc. Such sensors may include at least one of PH, density, sonar and magnetic resonance sensors, for example. Illustratively, the magnetic resonance sensors may be configured to provide information on atomic or molecular level to further identify the tissue or tumor under test.

Of course, the manipulating instrument 110 and manipulation site 115 need not be related to medicine. By way of non-limiting examples, manipulating instruments and sites may be related to handling or monitoring material and sites that are potentially hazardous including chemicals, radioactive, explosive and infectious material and sites, etc. Further, the manipulating instrument 110 may be used remotely in remote sites, such as related to space and underwater explorations, mining operations, remote medical operations, rescue operations, etc.

The pair of detectors 130, 135 is separated by a predetermined known distance, which may be variably controlled so as to provide three-dimensional (3-D) stereoscopic images with depth perception as is well known in the art of 3-D imaging, where knowing the separation distance between the two detectors, which may be charge-coupled device (CCD) cameras, right and left images (which are different from each other) are alternately or simultaneously provided on a display monitor or directly to the retina/eye of the operator. Of course, various mirrors, objective lens types or systems may be also be provided, e.g. in front of the CCDs 130, 135, such as for providing wide angle, panoramic and/or zoom views. Further multiple detectors may also be provided that are configured to capture and create holographic images of the manipulation site which are projected for viewing by multiple users, in addition to the operator of the manipulator 105. U.S. Patent No. 5,751,341 to Chaleki, entitled "Stereoscopic Endoscope System" describes two CCDs configured to provide 3-D stereoscopic images, with associated objective lens systems, controllers or processors, sensors, display monitors, projectors and special polarized eyeglasses or passive and active eyewear or headsets for 3-D viewing, communication means, movement/rotation/guidance means and the like. As is also well know in the art, the distance between the eyes of the viewer/operator may also be taken into account for improved 3-D viewing, as described in U.S. Patent Application Publication Nos. 2006/0055773, 2006/0038880, 2006/0038881, 2006/0036383, 2006/0012753, and 2006/0012674. Heads up displays for providing 3-D and/or stereoscoping images of the manipulation site may also be provided.

It is desirable to have a set default separation (which may be programmable and thus also controllable to provide better images, e.g., to suit the distance between the operator's eyes) between the pair of detectors 130, 135 so that the detectors return to the default position (e.g., after being independently controlled and moved), such as in response to a user input (such as an activation of a button on the interface 125 and/or joystick 175), or automatically in response to detection of unacceptable rendered images. The rendered images, such as displayed or projected on a medium, (whether 2-D or 3-D, such as stereoscopic or holographic images,) or directly into the viewer's eyes, include images of the manipulation site 115, captured by the pair of detectors 130, 135 and/or further multiple detectors, which may be provided as needed for capturing holographic images.

In the case of stereoscopic images, the right detector 130 captures a right image of the manipulation site 115, and the left detector 135 captures a left image which is different from the right image. The right and left images are then simultaneously or alternately provided to a medium, e.g., a screen, a liquid crystal display (LCD) or plasma monitor, or directly to the right and left eyes of a user of the manipulator system 100. High definition (HD) images may be displayed on small right and left HD LCD or plasma displays mounted on eyewear or headset worn by the user, for providing different right and left images in front of or to the right and left user eyes, resulting in a 3-D image as viewed by the user. Of course, other gear may also be used for viewing the 3-D stereoscopic or holographic images, such as helmets configured to provide heads-up displays on suitable mediums or surface(s) as described. It should be noted that reference to 3-D images is not limited to stereoscopic images, and may also include other images, such as holographic images. Similarly, reference to stereoscopic images may include other type of 3-D images such as holographic images.

Illustratively, the right and left images are simultaneously or alternately displayed or projected on the medium so as to provide 3-D stereoscopic images with depth perception. As is well know in the art of 3-D imaging, there are various ways to provide 3-D imaging for viewing with or without special glasses having special lenses such as lenses with different polarization, as described in U.S. Patent Application Publication No. 2005/0065658 to Green, entitled "Flexible Robotic Surgery System and Method;" U.S. Patent Application Publication No. 2005/0065657 to Green, entitled "Computed pivotal center surgical robotic system and method;" U.S. Patent No. 6,731,988 to Green, entitled "System and Method for Remote Endoscopic Surgery;" U.S. Patent No. 6,223,100 to Green, entitled "Apparatus and Method for Performing Computer Enhanced Surgery with Articulated Instrument." Some of the other well known methods of forming and viewing 3-D images include using parallax computed holographic displays, as described in U.S. Patent No. 6,21 1,848 to Plesniak, entitled "Dynamic Holographic Video with Haptic Interaction."

As is well known in the art of 3-D imaging, it may be desirable to configure the 3-D images for viewing without any special glasses, as described in WO 96/35975 to White, entitled "Device and Method for Superimposing Images in a Three-Dimensional Setting without Using Lenses." For example, the right and left images may be simultaneously or alternately projected directly into the operator's eyes, or onto lenses of glasses worn by the user of the manipulator system 100. Of course, the images may also be projected on any desired projection surface such as a heads-up displays where, for example, the user wears a helmet, goggles, glasses or any other headpiece, where right and left images are projected onto the right and left lenses of the headpiece, or onto small right and left HD LCD or plasma displays located a few inches away form the user's eyes. Of course, the images of the manipulation site 115 may also be provided as holographic images projected onto a medium for viewing by multiple viewers.

Typically, for precision operations such as medical procedures, as well as operations dealing with hazardous material including explosive, chemical, biological, radioactive material and the like, or operations in limited space such as mining operation including space and underwater exploration, it is desirable to have a footprint, e.g., diameter, of the manipulator 105 that substantially matches the manipulation site, or at least an access opening thereof. In an illustrative example related to medical surgical operations, it is desirable to have the manipulator footprint be as small as possible, particularly for minimumally invasive operations, where the manipulator 105 is inserted into the body through a small incision of less than 10mm, typically of the order of 2-4mm, where each CCD is approximately l-2mm or less, and is located substantially at the tip of the manipulating instrument 110, including being rotateable and movable in any direction or orientation, e.g., controlled by the interface 125 or a control device, such as a joystick 175, or manually controllable by the operator hand(s), to provide eyeballs on the manipulating instrument 110 capable of providing images around corners or obstacles etc.

Currently, endoscopes are used having a housing through which various instruments are inserted into the body where CCD cameras may be provided on the endoscope housing, as described in U.S. Patent No. 5,751,341. The present system dispenses with the housing to further reduce the instrument footprint as well as reduce the size of the incision or required entry/access opening. The reduced footprint allows insertions and guidance of the manipulating system 100 through reduced openings, and provides for better and more precise guidance and manipulation of the manipulator 105 to the manipulation site 115.

The detectors 130, 135 are connectable to the interface 125 through a first connection 140, while the manipulating instrument 110 is connectable to the interface 125 through a second connection 145. Of course, the two connections may be integrated into a single connection that provides for electrical and/or mechanical connection of the detectors 130, 135 and manipulating instrument 110 with the interface 125. The electrical connections may be a wired or wireless connections for communication amongst the various system elements, such as amongst the detectors 130, 135, manipulating instrument 110, interface 125, controller/processor 160, memory 170, force detector 180, display 165 and a control interface, such as the joystick 175, roller ball and the like. The wired connection may by any means such as using conductors or fiber optics. Similarly, any type of wireless communications may be used, such as Bluetooth for example, in the case of the various elements are in relatively close proximity to each other. Of course, signals for communication and control for example may also be communicated via other networks, whether local area networks (LANs) or wide area networks (WANs), such as the Internet. Signals may also be communicated over very long ranges, such as the case for space exploration.

The mechanical connection between one or both detectors 130, 135 and/or the manipulating instrument 110 on one hand, and the interface 125 and/or a holder for manual manipulation (by the operator to manipulate the holder) on the other hand may be through a guide(s) which may also provide an electrical/optical communication link in addition to a mechanical link. The guïde(s) 140, 145 may be flexible in one state for advancing and guiding the detectors 130, 135 and/or manipulating instrument 110 to the manipulation site 115. Once the detectors 130, 135 and/or manipulating instrument 110 are positioned in the desired location, the flexible guide(s) may be rendered rigid to hold the detectors 130, 135 and/or manipulating instrument 110 in the desired position(s), or to allow for more precise manipulation and control. For example, the guide(s) may be formed from a material that changes state in response to a stimuli, such as an electric current, and electromagnetic field, as well as in response to changes in pneumatic or hydraulic pressure, which may be provided in response to operator action for example, where fluid such as air or liquids may be forced into a hollow flexible guide (or a guide having a channel), where a certain pressure is maintained, thus rendering the guide as rigid as desired. The flexibility and malleability of the guides may also be changed in response to detecting a predetermined force, for example, to prevent damage to the environment or manipulation site by pushing or pulling the guides too hard in their rigid state. When a manipulating force exerted on the detectors 130, 135 and/or manipulating instrument 110 exceeds the predetermined threshold, which may be automatically or manually variably set in response to detecting the softness or hardness of the environment, the state of the guides may change from rigid to flexible, for example. The degree of flexibility and/or rigidity may also be controllable to achieve, manually or automatically, the desired amount or degree of flexibility/ rigidity.

The rigid state of the guide(s) holding the detectors 130, 135 may include a predetermined position or separation between to the two or more detectors 130, 135 for providing suitable 3-D stereoscopic and/or holographic images. Thus, in response to user activation or detection of unacceptable images, the separation between the two detectors 130, 135 returns to a predetermined programmable value.

As shown in FIG 1, the controller 160 is connectable to the interface 125, and is configured to control movement of the manipulating instrument 110 and the pair of detectors 130, 135. As already described, an operator such as a surgeon may hold the proximal end, e.g., via a suitable holder or interface 125, to manually control the manipulating or measuring instrument 110 and/or the detectors 130, 135 to manipulate material, such as tissues in the case of medical applications, at or take measurements of the material/tissue at the manipulation site to determine material/tissue characteristics, such as type, size, composition, etc, using various sensors such as PH, density, hardness, sonar, magnetic resonance sensors/detectors and any other sensor configured to sense and detect any desired aspect(s) of the manipulation site, such as temperature, pressure, atmospheric or ambient conditions and the like, where the manipulation site may be any site, such as within a biological body, under ground or under water, or anywhere including planets, moons and space. Accordingly, it should be understood that the interface 125 includes the hand of the operator, a robotic arm controlled by the operator via the joystick 175 for example, and/or any other suitable device configured to provide manipulation of the manipulating instrument 110 and/or the detectors 130, 135 which may be CCD detectors and/or any other type of detector, such as detectors to determine various aspects of the environment, such as PH, density, hardness/softness, composition, temperature, pressure, etc. Accordingly, it should be understood when detectors are referred to herein, whether the CCD detectors 130, 135 or force detector 180, that any other detector(s) may be included in addition or instead of such CCD or force detectors, to detect any desired aspect of the manipulation site 115 including, for medical applications, detectors configured to differentiate between normal or healthy tissues and abnormal tissues including detectors that are configured to determine the type of tissues and/or tumors substantially at or near the manipulation site 115. That is the descriptions related to CCD detectors 130, 135 or force detector 180, including interconnections thereof, are substantially equally applicable any other detector(s) and interconnections thereof, for example. A display device 165 is also connectable to the interface 125, where the controller 160, alone or in conjunction with a display controller of the display device 165, processes stereoscopic images received from the pair of detectors 130, 135 for display on the display device 165.

It should be understood that one type of sensor or detector, alone or in combination with other sensor(s)/detector(s) may be attached to the manipulating instrument 110, such as attached to the tip thereof, or provided on its own separate and/or independent guide for separate and independent manipulation, insertion, and/or control. For example, detector(s) configured to measure one or more aspects of material at the manipulation site 115, such as to distinguish between normal and abnormal tissue and/or determine tissue type may be removably or fixedly attached to the distal end 107 of the manipulating instrument 110, or a separate guide without CCD detectors. The detector(s) attached to manipulating instrument 110 or a separate guide may be guided to the manipulation site 115 by any means, such as using a navigation system that provides the user, e.g., operating surgeon, with indications and feedback related to guiding the detector(s) to the manipulation site 115, such as via xyz-coordinates, audio and/or video information, and the like. Various mapping may be used in conjunction with the navigation system to provide desired location information and guidance for guiding the manipulating instrument 110 and detector(s) to any desired location or manipulation site 115.

In medical applications, for example, the navigation system may access a mapping of the operating room, including the position of the patient, operating surgeon and the distal end of the manipulating instrument 110 and/or the detector(s) attached thereto, in conjunction with a mapping of the patient, e.g., via MRI images and the like, to provide instructions or feedback to the operating surgeon for properly directing the detectors located at the tip of a guide or the distal end 107 of the manipulating instrument 110 to the manipulation site 115. Such instructions may include distance and direction information for moving the manipulating instrument 110 within the patient, such as '2cm in,' 'lcm up', '4mm right,' and the like.

The manipulating instrument 110 and/or the pair of detectors 130, 135 (and/or any further detectors) may be connected to the interface 125 by a flexible shaft(s) or guide(s) that includes the connections 14O$_{5}$ 145, e.g., having a guide(s) with different states (rigid and flexible) as described, for insertion and guidance thereof to the manipulation site 110. Illustratively, one guide is provided between the manipulating instrument 110 and the interface 125, where the pair of detectors 130, 135 is mounted on the manipulation site 110, and may also communicate with the interface 125 through the guide which may include the connections 140, 145, such as wire, fiber optic, etc. Alternatively, or in addition, the pair of detectors 130, 135 communicates with the interface 125 or directly with the controller 160 and/or the display 165 by other means, such as by wireless communication, where wireless communication may also be used in addition to, or instead of, wired communication between the manipulating instrument 110 and the controller 160 and/or other devices, such a remote controller or joystick 175.

Communication wiring and/or a fiber optic bundle itself may be used as the flexible guide thus further reducing the footprint of the manipulator 105 and the size requirement of any openings for insertion and guidance of the manipulator 105. Thus, unlike conventional endoscopes having a housing that are used for insertions of desired instruments thereto for reaching a manipulation site, the manipulation 105 does not require such a housing. Rather, the flexible guide itself is fixedly or removably attached to the manipulating instrument 110 (and/or detectors 130, 135 in the case where the detectors 130, 135 are not attached to the manipulating instrument 110 and have their own flexible guide(s)) for insertion and guidance thereof to the manipulation site 115.

Of course, an optional housing 150 may be provided if desired. In this case, the housing 150 itself need not reach or be inserted all the way to the manipulation site. Rather, the pair of detectors 130, 135, which are not mounted on the housing, but rather are mounted on the manipulation instrument 110 itself (or provided on separate a flexible guide(s) that may be rendered rigid as described), may extend beyond the housing 150 to reach or be closer to the manipulation site 115 than the housing 150, and/or be co-located at the manipulation site 115 with the manipulating instrument 110.

FIG 2-3 show embodiments of the manipulator instrument 110 and detectors 130, 135 in greater detail. As shown in FIGs 2-3, the detectors 130, 135 are attachable to the manipulator instrument 110 and each may have its own attachment member 210, 220 which may be telescopic and thus extendable under the control of the controller 160. The attachment members 210, 220 and thus the detectors 130, 135 may be fixedly attached at a fixed distance therebetween. Alternatively, the detector member 210, 220 may be movable in unison to change direction and orientation of the detectors 130, 135, It should be noted that the distance between the two detectors 130, 135 may be maintained at a fixed distance while their direction and orientation are changed in unison. Alternatively, the distance between the two detectors 130, 135 may be changed by moving apart or closer the detector members 210, 220, as shown in FIG 3. Each detector may be independently moveable, for example, to provide mono-images of desired areas where stereoscopic images may be difficult to obtain, such as when both detectors cannot be moved in unison to point to a particular direction .

The distance between the two detectors 130, 135 may be continuously changeable or changed between predetermined values. For examples, the separation or distance between the two detectors 130, 135 may be selectable from a set of predetermined values, such as lmm, 1.2 mm, 1.4mm etc. Alternatively or additionally, the distance may be stepped in programmable steps or increments, or directly changed from one value to another, such as from lmm to 2mm. As is well known in the art, the distance between the two detectors 130, 135 is used by a processor or controller to generate the 3-D images. The distance between the two detectors 130, 135 may be determined in view of their moving apart or together in known predetermined or programmable steps. Alternatively or in addition, sensors may be provided to measure and calculate the distance between the two detectors 130, 135.

The detectors 130, 135 themselves, their members 130, 135, or the detector(s)-member(s) combination(s) may each be removably attachable to the manipulator instrument 110. Of course, in the case where more than one manipulator instrument 110 is provided, each or any desired number of manipulator instruments may have their own pair of detectors to provide 3-D stereoscopic images of the site where the particular manipulator instrument is pointed to. For example as shown in FIG 4, one manipulator instrument 410 may be configured to cut or pulverize a tumor, while another manipulator instrument may be configured for suction of the cut/pulverized tissue. Of course, further detectors and/or manipulator instrument may be provided with any further desired detectors, such as detectors configured to distinguish between desired and undesired matter near the manipulation site, such as to distinguish between normal tissue and abnormal tissue or tumors or tumor types, in the case of medical applications. In this embodiment, each manipulator instrument 410, 420 has its own pair of detectors 430, 435 and 440, 445, respectively. Of course, any one of the manipulator instruments may only have a single detector 510, 520, as shown in FIG 5, alone or combined with further manipulator instrument(s) 530 with pair of detectors 540, 545.

In the case where two different further manipulator instruments, each having a single detector, are moved in unison, the two detectors of each instrument may form a pair of detectors for providing 3-D stereoscopic images.

Returning to FIGs 1-3, illustratively, the detector members 210, 220 separately or collectively are movable to orient the detector(s) to any desired direction, under the control of the controller 160, which may be manually controlled by the user of the manipulating system in a manual mode, or automatically in an automatic mode. In the automatic mode, the detectors may be configured to pan the overall region or manipulation site 115 and detect regions of anomalies which are different from neighboring areas, e.g., to map the overall area and distinguish and/or identify such areas of anomalies. Further operation and/or display modes also include stereoscopic and mono modes, where in the stereoscopic mode the two detectors 130, 135 move together separated by a known distance used for providing 3-D/stereoscopic images. In the mono mode, each detector is controlled and moved independently of each other to provide a mono-image of a site that may be located in an area where an acceptable 3-D image is difficult to obtain. For example, the right detector 130 may be independently moved (e.g., including pan/tilt/zoom) to the extreme right and even backward to provide mono views are such areas.

The manipulating instrument 110 may be any desired instrument suitable for a particular manipulation and may have one or more probes, where illustratively two and three probes are shown in FIGs 4-5, respectively. The probe(s) may be configured to perform various tasks, such as pick and place, cut, heat, cool, pulverize, etc. For example in a medical application, one probe may include a laser for heating, burning, cutting tumors or shaving the capsule of a tumor or an ultrasound transducer for pulverizing unwanted tissue, while the other probe may be configured to provide suction or the detached unwanted tissue. The probes, in conjunction with proper data processing by a processor of the controller 160 (or other processors which are operationally coupled to the detectors via any type of link, such as wired or wireless including via networks, LANs or WANs such as the Internet using collected data as well as data stored in the memory 170 or other memory as needed,) may also be configured to test and determine tissue type, distinguish between normal or healthy and abnormal tissue, collect samples, such as sample tissues for biopsy, or other samples in space, mining or underwater explorations.

Of course, the detectors 130, 135 themselves, or other detectors may be fixedly or removably attached to the probes themselves, as desired, and may include any type of detector, and are not limited to image detectors form providing images. For example, the detectors may be configured *to* detect hazardous or any other material, such as explosive, chemical, biological to radioactive material, as well as particular material for example associated with mining operations, such as detecting gold, diamond, coal, oil, etc., including being configured to perform tests or collect data to identify material near the manipulation site, typically used in exploration of unknown and remote areas of any object, such as a biological body, areas of earth, other planets, moons, atmosphere, space, etc.

Alternately or in addition to the image detectors 130, 135, a further detector(s) 180 may be provided configured to detect and provide force information, to allow for a refined manipulation where forces and position of the manipulating instrument relative to its environment are detected. For example, a sonar sensor(s) may be used to determine proximity or distance of objects from the sensor(s). Each manipulating instrument 110 may have its own force detector 180 or other detectors such as a sonar transceiver that transmits signals, such as sound waves to determine distance(s) to objects based on received sound waves reflected from objects. Of course, more than one sonar and/or force detector 180 may be provided on each manipulating instrument 110 as needed, such as when the manipulating instrument 110 has several members, where two such members 185, 190 are shown in FIG 1. Thus, a force detector 180 may be provided on each member 185, 190.

The detected force is feedback to the user, in response to which actuators or force generators operate to provide a more realistic feeling of the remote manipulation site for more precise exertion of desired forces. Thus, the user feels as if being present at the remote manipulation site 110, by viewing 3-D stereoscopic images as well as feeling and interacting with the manipulation site 110 and/or a synthetic image/object thereof that simulate the properties of the manipulation site 110.

Force detectors and generators, position sensors and actuators for providing force sensation and feeling of remote sites are well known, as described in U.S. Patent Application Publication No. 2005/0065658 to Green, FR 02847995 A1 to Trousset, U.S. Patent No. 6,290,649 to Miller, U.S. Patent No. 6,211,848 to Plesniak, and U.S. Patent No. 6,046,727 to Rosenberg.

The controller 160 may be any type of controller and/or processor and may be programmable, where programs, software and other data are stored in the memory 170 or additional memories that are operationally coupled to each other and the controller 160 and other elements of the manipulating system 100. Thus, the controller 160, the memory 170, the interface 125, the display 165, the joystick 175 and any other input/output (I/O) or peripheral device, may all be operationally coupled to each other as needed. The memory 170 may be any type of device for storing application data as well as other data. The various component of the system may be operationally coupled to each other by any type of link, including wired or wireless link(s), for example.

Such software can of course be embodied in any computer-readable medium, such as an integrated chip, a peripheral device or memory, such as the memory 170 or other memory coupled to the controller/processor 160, which may be a dedicated processor for performing in accordance with the present system, or may be a general-purpose processor wherein oniy one of many functions operates for performing in accordance with the present system. The processor may operate utilizing a program portion, multiple program segments, or may be a hardware device utilizing a dedicated or multi-purpose integrated circuit. Each of the above systems utilized for identifying the presence and identity of the user may be utilized in conjunction with further systems.

The computer-readable medium and/or memory 170 may be long-term, short-term, or a combination of long-term and short-term memories, or any recordable medium, (e.g., RAM, ROM, removable memory, CD-ROM, hard drives, DVD, floppy disks or memory cards) or may be a transmission medium (e.g., a network comprising fiber-optics, the world-wide web, cables, and/or a wireless channel using, for example, time-division multiple access, code-division multiple access, or other wireless communication systems). Any medium known or developed that can store information suitable for use with a computer system may be used as the computer-readable medium and/or memory 170.

These memories configure the processor 160 to implement the methods, operational acts, and functions disclosed herein. The memories may be distributed or local and the processor 160, where additional processors may be provided, may be distributed or singular. The memories may be implemented as electrical, magnetic or optical memory, or any combination of these or other types of storage devices. Moreover, the term "memory" should be construed broadly enough to encompass any information able to be read from or written to an address in the addressable space accessed by a processor. With this definition, information on a network is still within memory 170, for instance, because the processor 160 may retrieve the information from the network.

The processor 160 and memory 170 may be any type of processor/controller and memory, such as those described in U.S. 2003/0057887, which is incorporated herein by reference in its entirety. The processor 160 is capable of providing control signals and/or performing operations in response to input signals from the I/O devices such as the joystick 175 and/or other devices including independent control of CCD cameras 130, 135 and the manipulating instrument 110, and executing instructions stored in the memory 170. The processor 160 may be an application-specific or general-use integrated circuit(s). Further, the processor 160 may be a dedicated processor for performing in accordance with the present system or may be a general-purpose processor wherein only one of many functions operates for performing in accordance with the present system. The processor may operate utilizing a program portion, multiple program segments, or may be a hardware device utilizing a dedicated or multi-purpose integrated circuit. Each of the above systems utilized for identifying the presence and identity of the user may be utilized in conjunction with further systems.

Of course, it is to be appreciated that any one of the above embodiments or processes may be combined with one or with one or more other embodiments or processes to provide even further improvements in providing for accurate 3-D images and feeling of remote manipulation sites, as well as identifying and determining aspects of the environment substantially near or at the manipulation site, including identifying and determining type, size, density, PH, components, constitutions, composition and other characteristics of material substantially near or at the manipulation site using appropriate detectors, sensors, probes and the like, e.g., (fixedly or removably) attached to the manipulating instrument, and/or alongside the manipulating instrument (fixedly or removably) attached to their own guide(s) and/or controlled s) or processor(s) for independent control and information processing.

Finally, the above-discussion is intended to be merely illustrative of the present system and should not be construed as limiting the appended claims to any particular embodiment or group of embodiments. Thus, while the present system has been described in particular detail with reference to specific exemplary embodiments thereof, it should also be appreciated that numerous modifications and alternative embodiments may be devised by those having ordinary skill in the art without departing from the broader and intended spirit and scope of the present system as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative manner and are not intended to limit the scope of the appended claims.

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;

e) any of the disclosed elements may be comprised of hardware portions (e.g., including discrete and integrated electronic circuitry), software portions (e.g., computer programming), and any combination thereof;

f) hardware portions may be comprised of one or both of analog and digital portions;

g) any of the disclosed devices or portions thereof may be combined together or separated into further portions unless specifically stated otherwise; and

h) no specific sequence of acts or steps is intended to be required unless specifically indicated.

What is claimed is:

1. A manipulator comprising:

a distal end having a manipulating instrument configured for manipulation at a manipulation site;

a proximate end connectable to an interface; and

a pair of detectors configured to capture stereoscopic images of said manipulation site; said pair of detectors being configured for a first connection to said interface, and said manipulating instrument being further configured for a second connection to said interface;

wherein said pair of detectors is co-locatable at said manipulation site with said manipulating instrument.

2. The manipulator of claim 1, wherein said pair of detectors is removably attachable to said manipulating instrument.

3. The manipulator of claim 1, wherein at least one of said first connection and said second connection includes at least one of a wired and wireless connection.

4. The manipulator of claim 1, wherein at least one of said first connection and said second connection includes at least one a guide having a flexible state and a rigid state.

5. The manipulator of claim 4, wherein said at least one guide is configured for being in said flexible state for advancing at least one of said pair of detectors and said manipulating instrument toward said manipulation site, and wherein said at least one guide is configured for being in said rigid state for substantially holding said at least one of said pair of detectors and said manipulating instrument in a desired position.

6. The manipulator of claim 1, wherein said pair of detectors are configured for individual control and movement for further providing individual non-stereoscopic images in a non-stereoscopic mode, and wherein said pair of detectors are provided with a default position relative each other for becoming separated by a default predetermined distance for

providing said stereoscopic images in a stereoscopic mode; wherein a separation between said pair of detectors is variable in said non-stereoscopic mode.

7. The manipulator of claim 1, further comprising a housing configured to facilitate providing said manipulating instrument and said pair of detectors to said manipulation site; said manipulating instrument and said pair of detectors being extendable beyond said housing for reaching said manipulation site.

8. The manipulator of claim 1, further comprising a controller connectable to said interface; said controller being configured to control movement of at least one of said manipulating instrument and said pair of detectors.

9. The manipulator of claim 1, further comprising a controller connectable to said interface; said controller being configured to process said stereoscopic images for display on a display device.

10. The manipulator of claim 9, wherein said display device includes at least one of a monitor, a heads-up display, a projector and eyeglasses.

11. The manipulator of claim 9, wherein said controller is configured to respond to commands from at least one of movement of a joystick and speech.

12. The manipulator of claim 1, wherein said interface is configured to allow manual manipulation of at least one of said manipulating instrument and said pair of detectors by a user of said manipulator.

13. The manipulator of claim 1, further comprising additional detectors configured to capture three dimensional images of said manipulating instrument.

14. The manipulator of claim 13, wherein said three dimensional images are renderable as holographic images.

15. The manipulator of claim 1, further comprising a force detector removably attached to at least one of said pair of detectors and said manipulating instrument.

16. The manipulator of claim 1, further comprising at least one environment measuring detector configured to determine at least one aspect substantially at the manipulation site, such as distinguish between healthy and abnormal tissue in medical applications.

17. The manipulator of claim 1, further comprising at least one detector configured to distinguish between normal and abnormal tissue at the manipulation site.

18. A manipulator comprising:

a distal end having a manipulating instrument configured for manipulation at a manipulation site;

a proximate end connectable to an interface; and

a detector configured to capture images of said manipulation site, said detector and said manipulating instrument being connected to said interface;

wherein said detector is co-Iocatable at said manipulation site with said manipulating instrument.

19. The manipulator of claim 18, wherein said detector is removably attachable to said manipulating instrument.

20. The manipulator of claim 18, wherein at least one of said first connection and said second connection includes at least one of a wired and wireless connection.

21. The manipulator of claim 18, wherein at least one of said first connection and said second connection includes at least one a guide having a flexible state and a rigid state.

22. The manipulator of claim 21, wherein said at least one guide is configured for being in said flexible state for advancing at least one of said detector and said manipulating

instrument toward said manipulation site, and wherein said at least one guide is configured for being in said rigid state for substantially holding said at least one of said detector and said manipulating instrument in a desired position.

23. The manipulator of claim 18, further comprising a further detector located at a predetermined distance from said detector, said detector and said further detector being configured to provide a stereoscopic image of said manipulation site.

24. The manipulator of claim 18, further comprising additional detectors configured to capture three dimensional images of said manipulating instrument.

25. The manipulator of claim 24, wherein said three dimensional images are renderable as holographic images.

26. The manipulator of claim 18, further comprising a housing configured to facilitate providing said manipulating instrument and said detector to said manipulation site; said manipulating instrument and said detector being extendable beyond said housing for reaching said manipulation site.

27. The manipulator of claim 18, further comprising a controller connectabïe to said interface; said controller being configured to control movement of at least one of said manipulating instrument and said detector.

28. The manipulator of claim 18, wherein said interface is configured to allow manual manipulation of at least one of said manipulating instrument and said detector by a user of said manipulator.

29. The manipulator of claim 18, further comprising a controller connectable to said interface; said controller being configured to process said images for display on a display device.

30. The manipulator of claim 29, wherein said display device includes at least one of a monitor, a heads-up display, a projector and eyeglasses.

31. The manipulator of claim 29, wherein said controller is configured to respond to commands from at least one of movement of a joystick and speech.

32. The manipulator of claim 18, further comprising a force detector removably attached to at least one of said detector and said manipulating instrument.

33. The manipulator of claim 18, further comprising at least one environment measuring detector configured to determine at least one aspect substantially at the manipulation site, such as distinguish between healthy and abnormal tissue in medical applications.

34. The manipulator of claim 18, further comprising at least one detector configured to distinguish between normal and abnormal tissue at the manipulation site.

35. A manipulation system comprising:

a manipulator having an interface at a proximal end, and a manipulating instrument and a pair of detectors at a distal end, said manipulating instrument being configured for manipulation at a manipulation site, and said pair of detectors being configured to capture stereoscopic images of said manipulation site, wherein said pair of detectors is further configured for a first connection to said interface, and said manipulating instrument is further configured for a second connection to said interface;

a controller connectable to said interface, said controller being configured to control movement of at least one of said manipulating instrument and said pair of detectors; and

a display device, wherein said controller is further configured to process said stereoscopic images for display on said display device;

wherein said pair of detectors is extendable beyond a housing of said manipulator.

36. The manipulation system of claim 35, further comprising a force detector attached to at least one of said pair of detectors and said manipulating instrument.

37. The manipulator system of claim 35, further comprising at least one environment measuring detector configured to determine at least one aspect substantially at the manipulation site, such as distinguish between healthy and abnormal tissue in medical applications.

38. The manipulator system of claim 35, further comprising at least one detector configured to distinguish between normal and abnormal tissue at the manipulation site.

39. A method of remotely manipulating a manipulation site comprising the acts of:

providing a manipulating instrument at said manipulation site;

attaching a pair of detectors to said manipulating instrument; and

controlling said pair of detectors to capture stereoscopic images of said manipulation site.

40. The method of claim 39, further comprising providing at least one detector at said manipulation site, said at least one detector being configured to distinguish between normal and abnormal tissue at said manipulation site.

41. The method of claim 39, wherein said pair of detectors is removably attached to said manipulating instrument.

42. A manipulator comprising:

a distal end having a manipulating instrument configured for manipulation at a manipulation site;

a proximate end connectable to an interface; and

at least one detector configured to take measurements at the manipulation site.

43. The manipulator of claim 42, wherein said at least one detector is co-locatable at said manipulation site with said manipulating instrument.

44. The manipulator of claim 42, wherein said detector is at least one of fixedly and removably attachable to said manipulating instrument.

45. The manipulator of claim 42, wherein said at least one detector is configured to distinguish between normal and abnormal tissue of a patient at the manipulation site.

46. The manipulator of claim 42, further comprising a processor configured to process said measurements and distinguish between normal and abnormal tissue of a patient at the manipulation site.

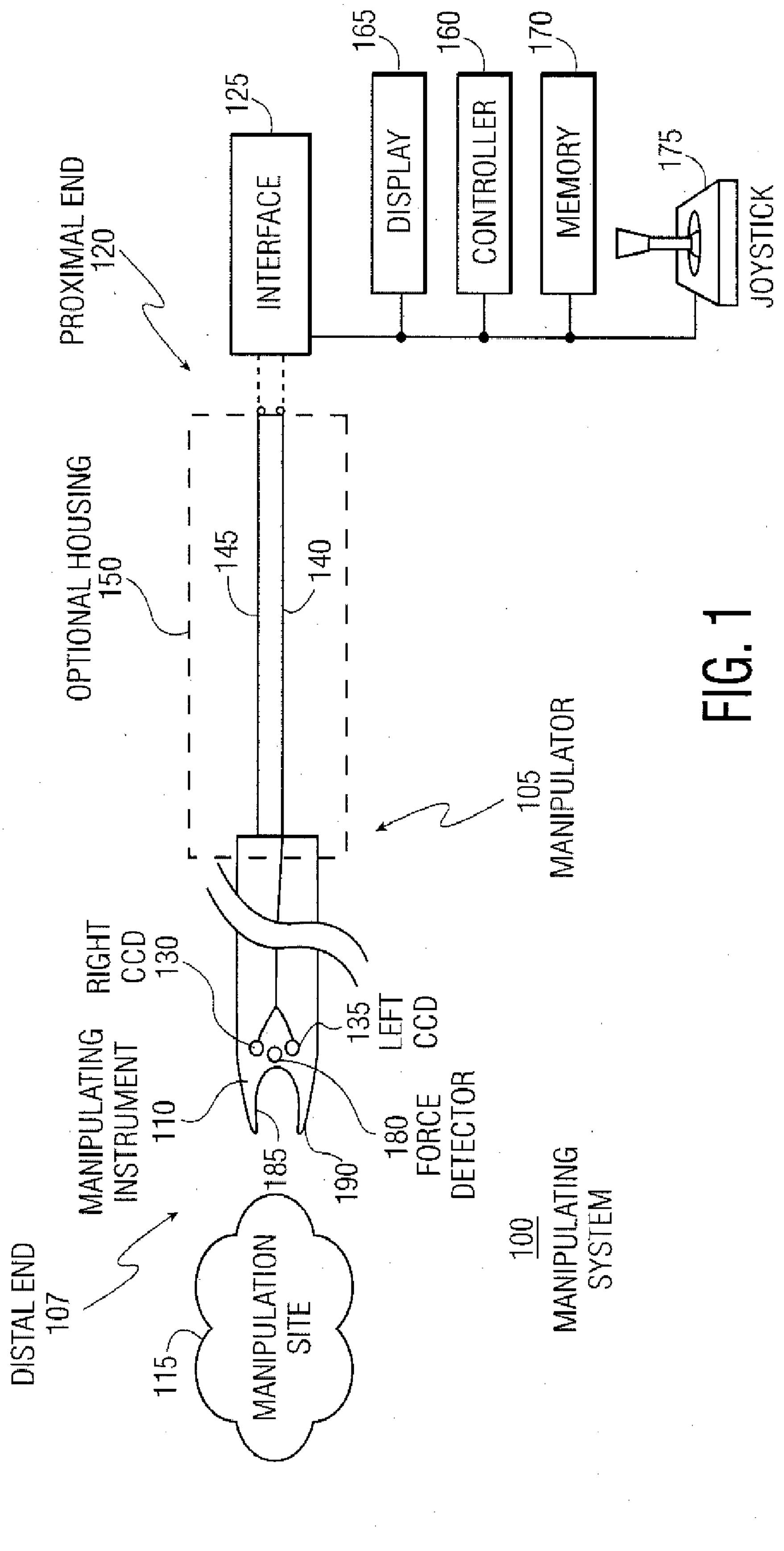
PROXIMAL END
120
INTERFACE
125
DISPLAY
165
CONTROLLER
160
MEMORY
170
175
JOYSTICK
OPTIONAL HOUSING
150
145
140
105
MANIPULATOR
RIGHT
CCD
130
135
LEFT
CCD
MANIPULATING
INSTRUMENT
110
180
FORCE
DETECTOR
185
190
DISTAL END
107
115
MANIPULATION
SITE
100
MANIPULATING
SYSTEM

FIG. 1

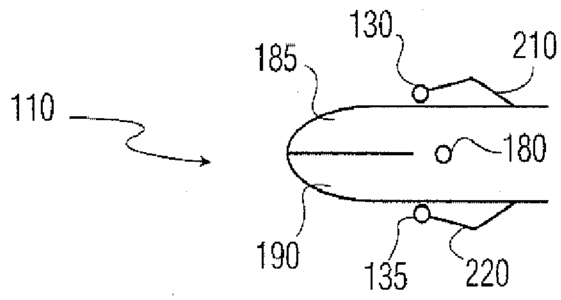

FIG. 2

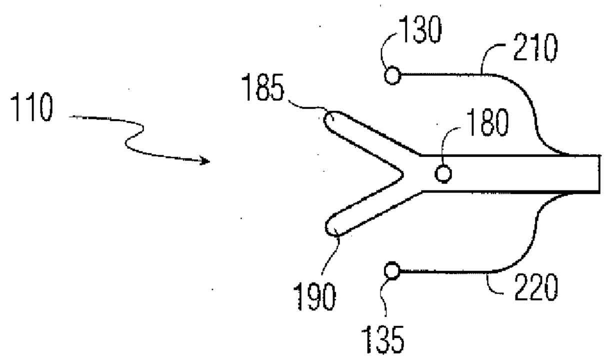

FIG. 3

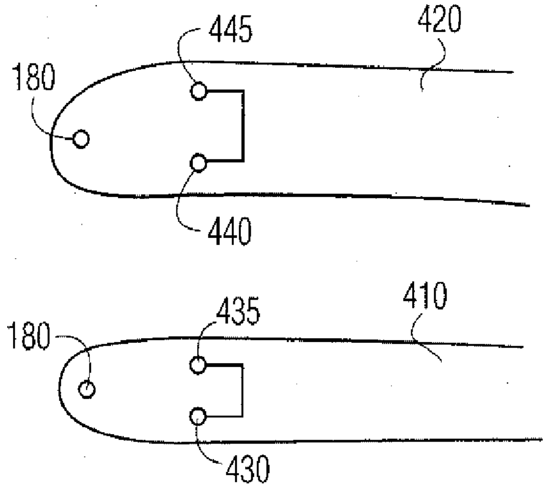

FIG. 4

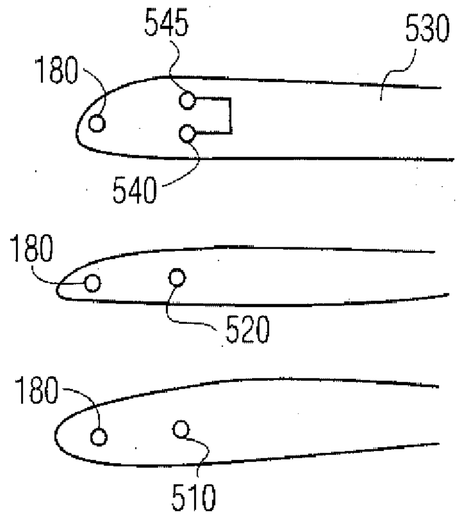

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT7US07/67357

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **A61B** 1/00(2006.01)

USPC: 600/104, 111

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)

U.S. : **600/104,1 11, 166, 106, 173, 182;** 348/45,65

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)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2005/0234296 A1 (SAADAT et al) 20 October 2005, see paragraphs [0002], [0028]-[0036].	1-10, 12,18-23,26-30,35,39-46 ----------- 11, 13-1 7,24,25,3 1-34,36-38
Y	US 2006/0015008 A1 (KENNEDY) 19 January 2006, see paragraph [0045].	11,3 1
Y	US 6,99 1,602 A (NAKAZAWA et al) 3 1 January 2006, see Figure 1.	13, 14,24,25
Y	US 6,8 17,973 B2 (MERRJL et al) 16 November 2004, see column 5, liens 64-67.	15,32,36
Y	US 5,547,455 A (MCKENNA et al) 20 August 1996, see column 9, lines 12-3 1.	16, 17,33,34,37,38

Further documents are listed in the continuation of Box C. D 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 published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cted 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 relevantE, 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 tie document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of this international search report
27 May 2008 (27.05.2008)	3 JUN 2008

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn ISA/US Commissioner for Patents P O Box 1450 Alexandria, Virginia 223 **13-1450** Facsimile No. (571) 273-3201	John P. Leubecker Telephone No. (571) 272-2975