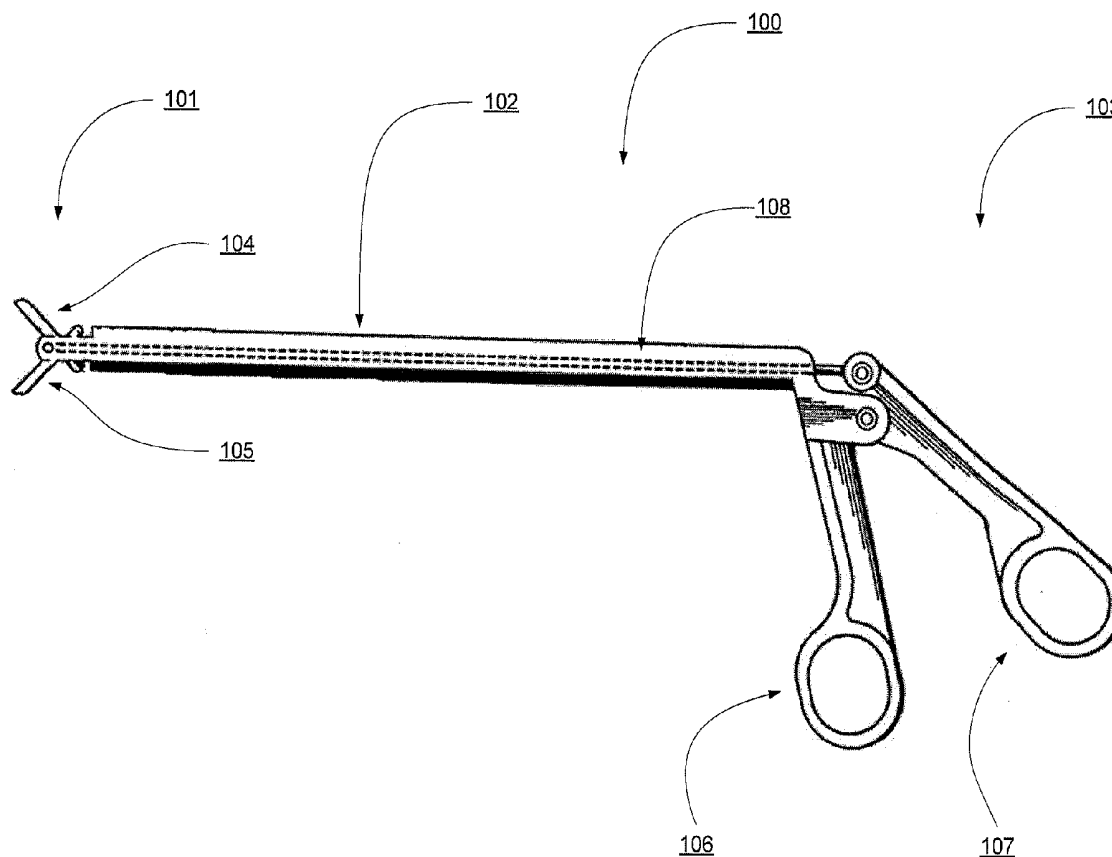




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Cohen et al.(10) **Pub. No.: US 2010/0069941 A1**(43) **Pub. Date: Mar. 18, 2010**(54) **SYSTEMS AND METHODS FOR SENSING
HAND MOTION BY MEASURING REMOTE
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A61B 17/00 (2006.01)(52) **U.S. Cl. 606/170; 606/1**(57) **ABSTRACT**

Systems and methods for sensing hand motion by measuring remote displacement are disclosed. For example, one disclosed apparatus includes a first surface configured to engage a first distal member of a surgical tool and a second surface configured to engage a second distal member of the surgical tool, the second surface coupled to the first surface at a pivot point. The apparatus further includes a sensor configured to detect a relative movement of the first surface and the second surface about the pivot point and to generate a signal based at least in part on the relative movement.



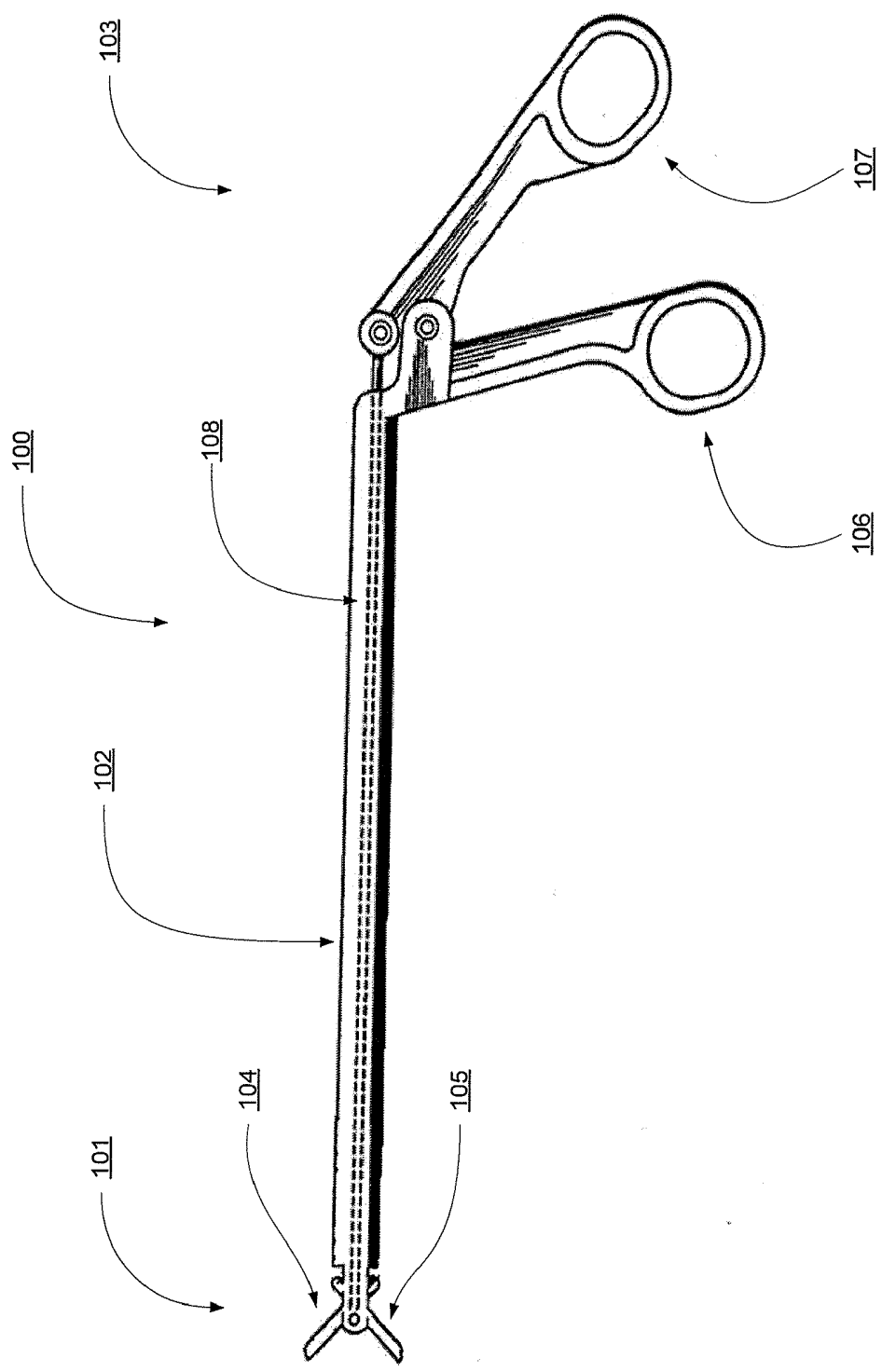


Figure 1

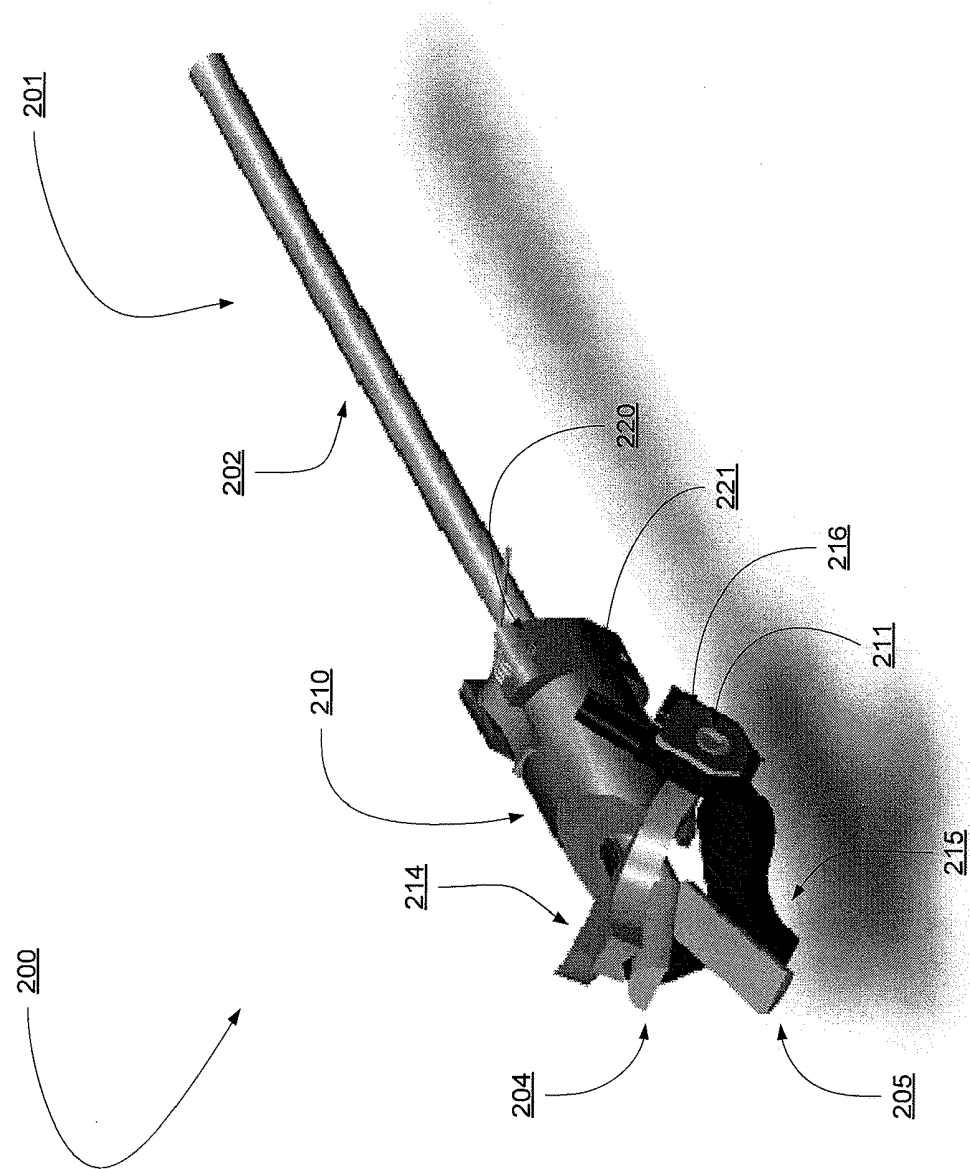


Figure 2

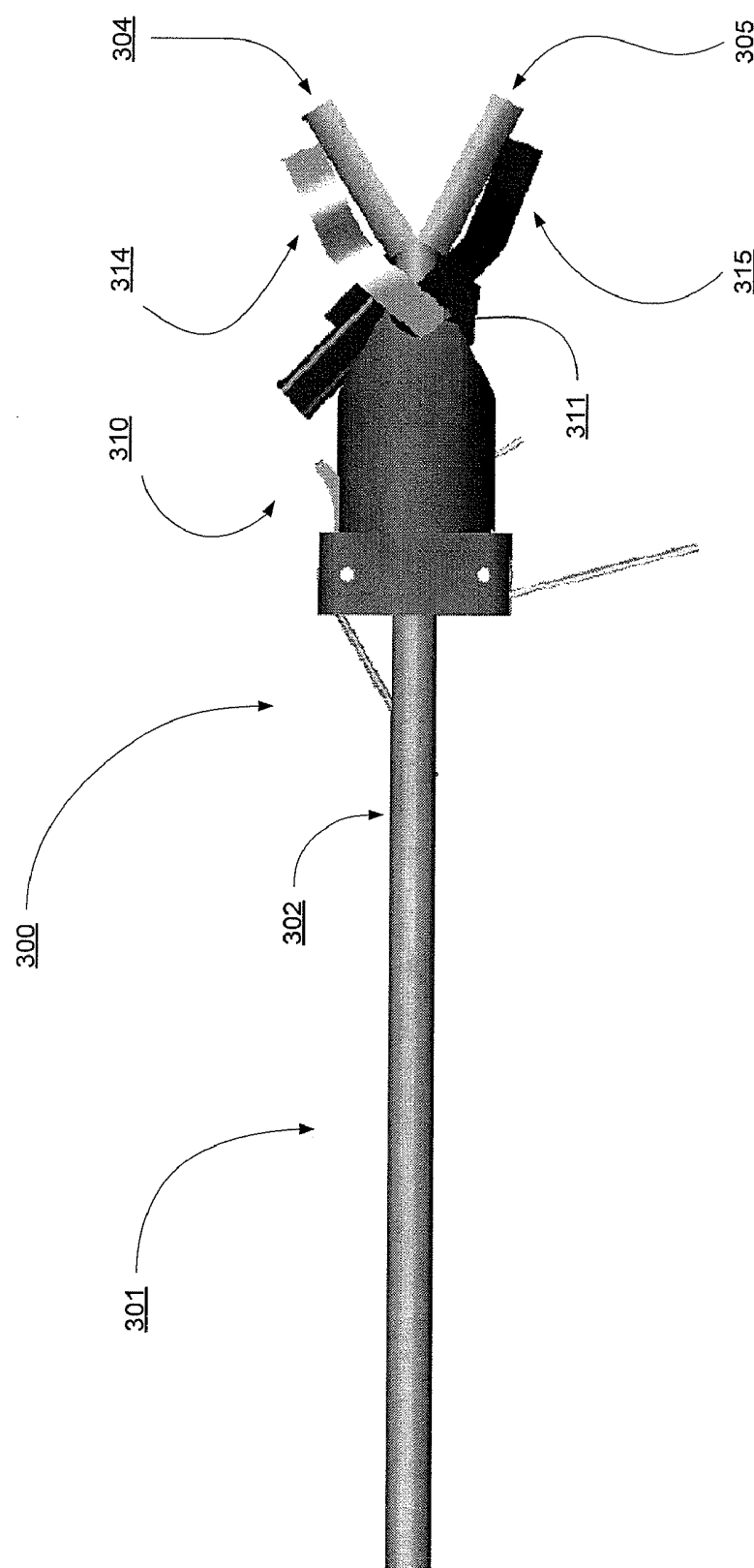


Figure 3A

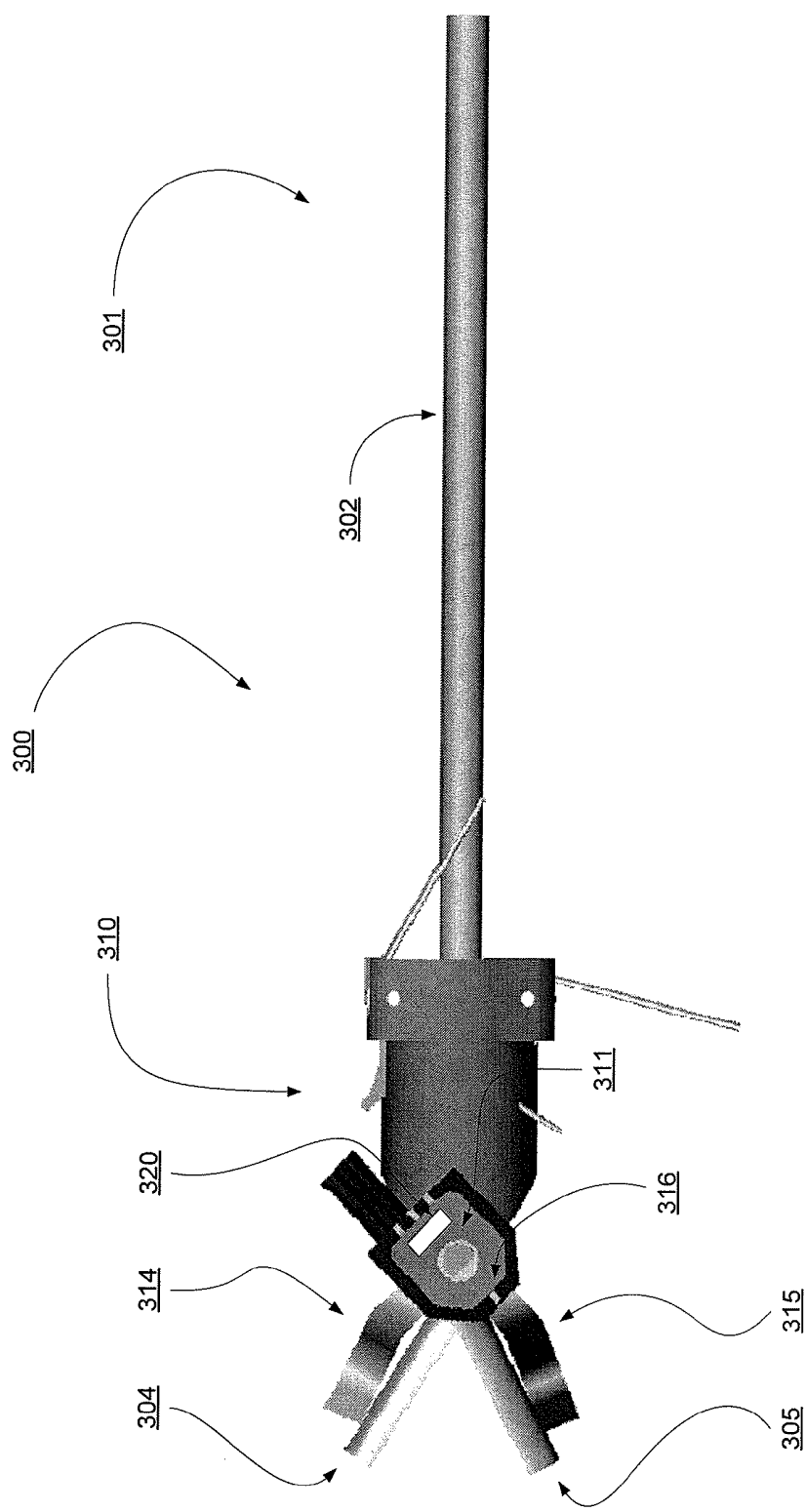


Figure 3B

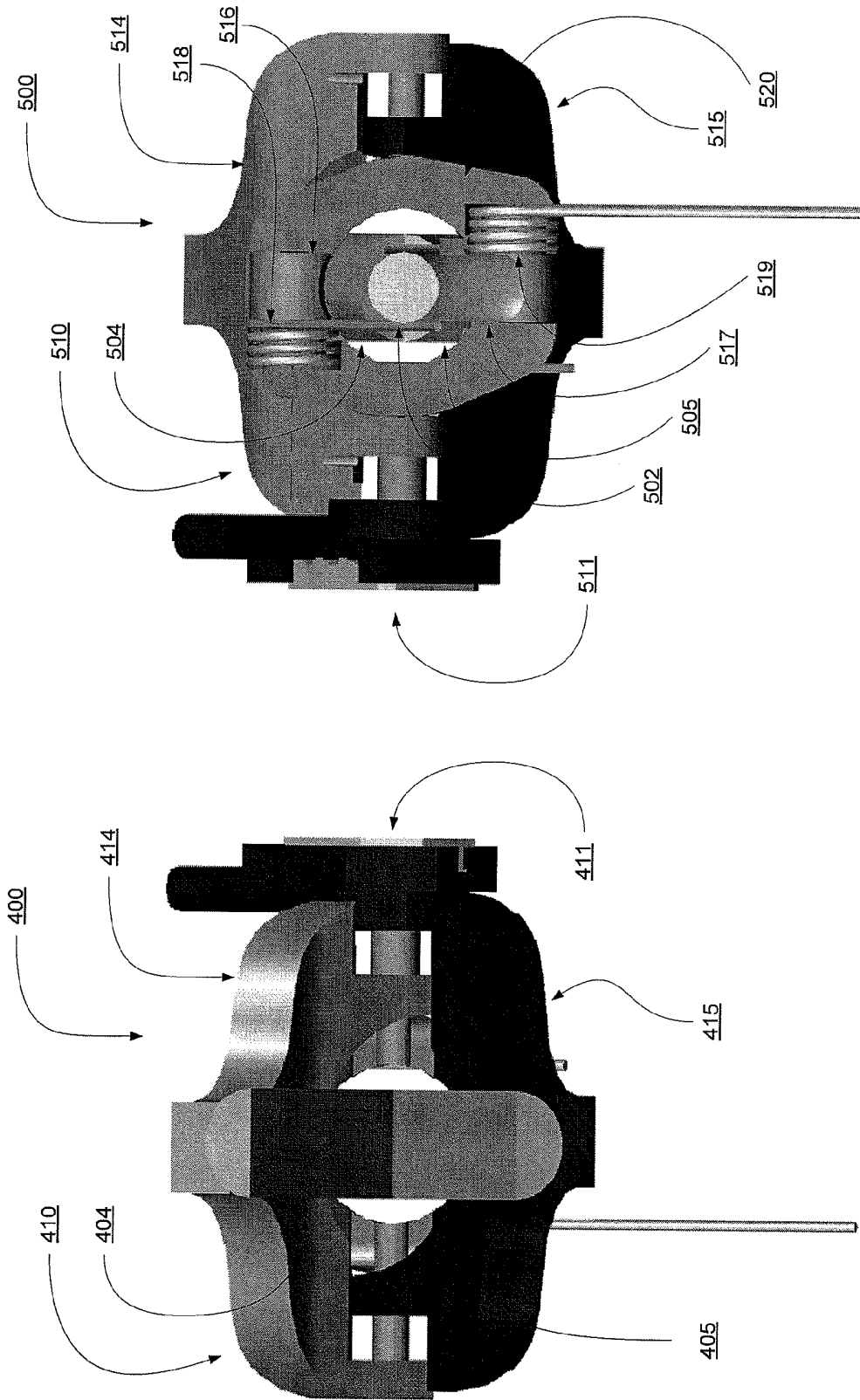


Figure 4

Figure 5

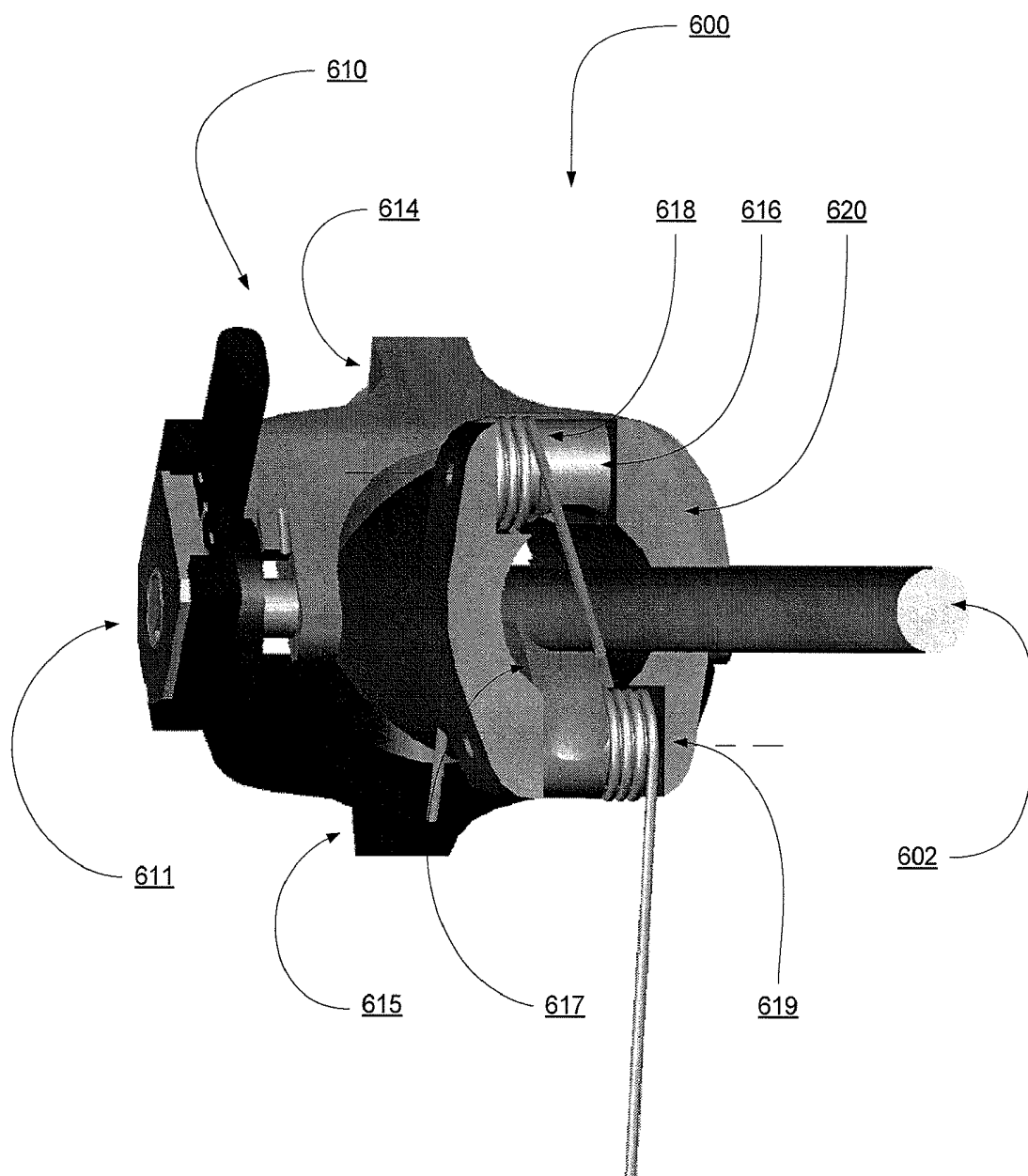


Figure 6

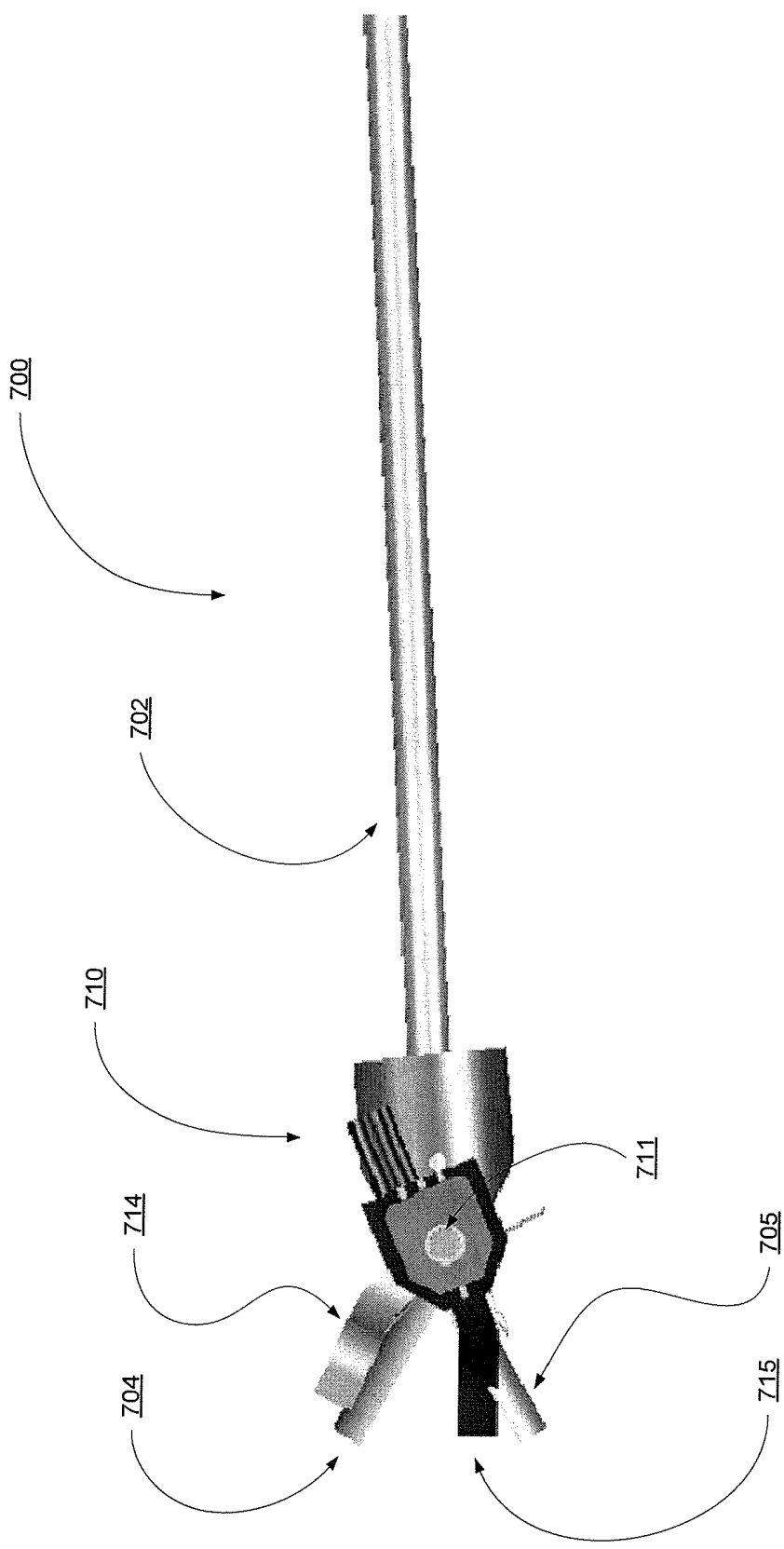


Figure 7

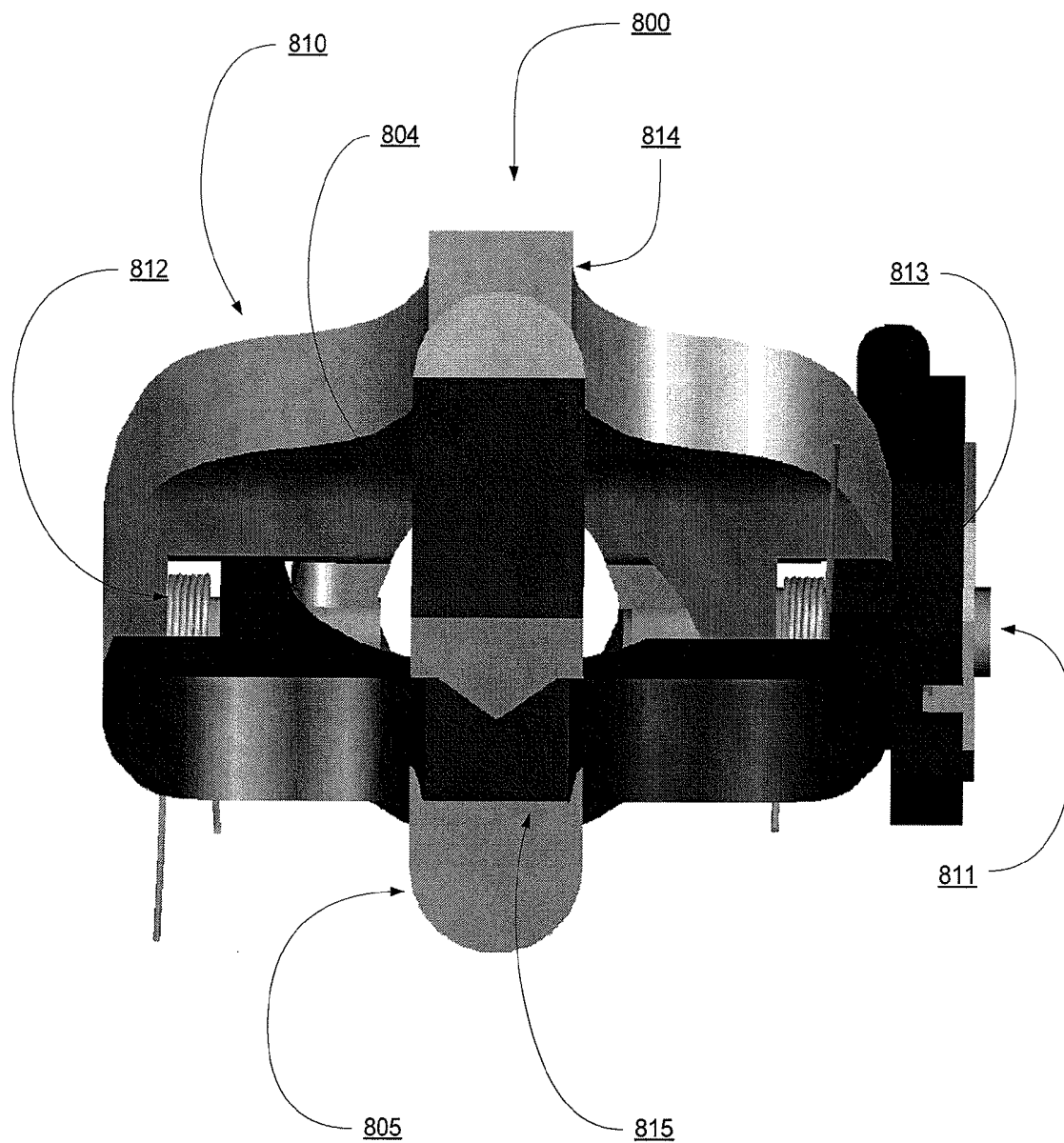
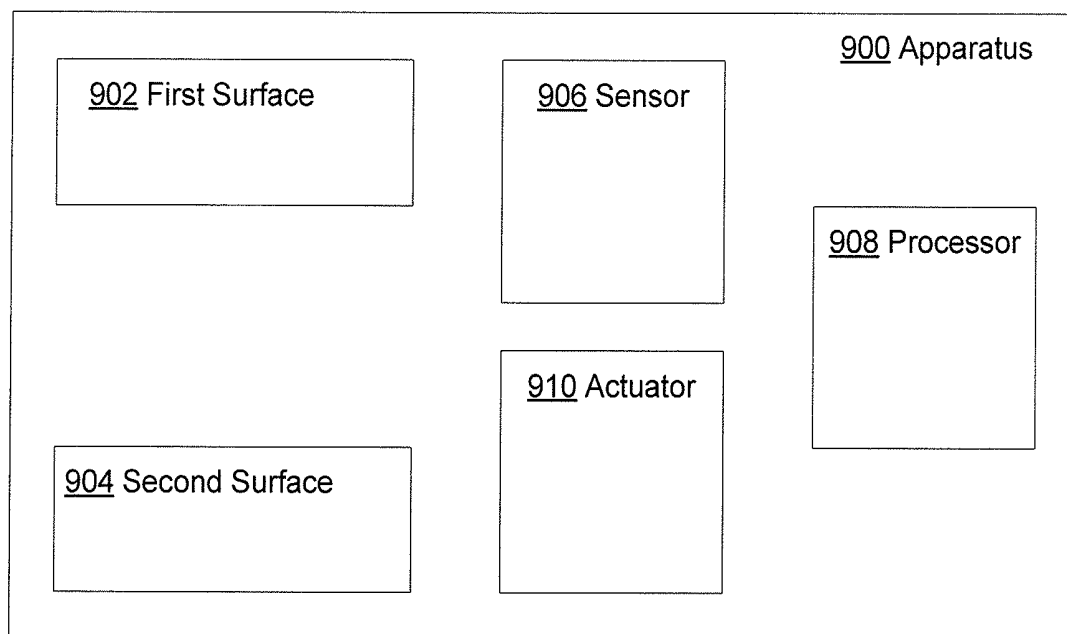
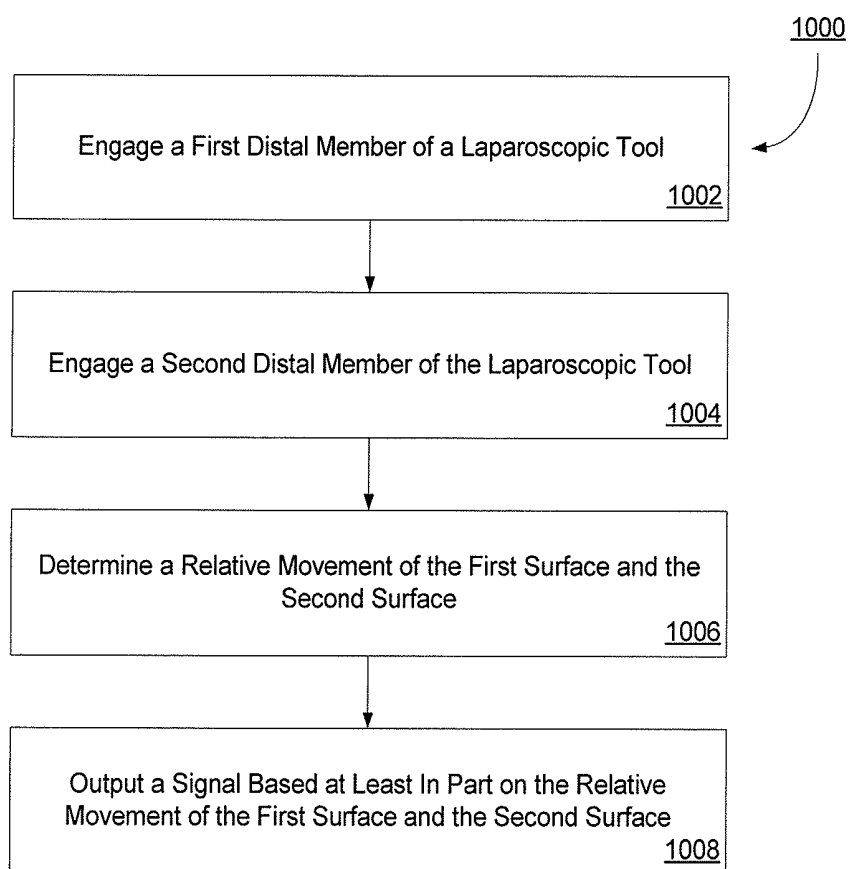


Figure 8

**Figure 9****Figure 10**

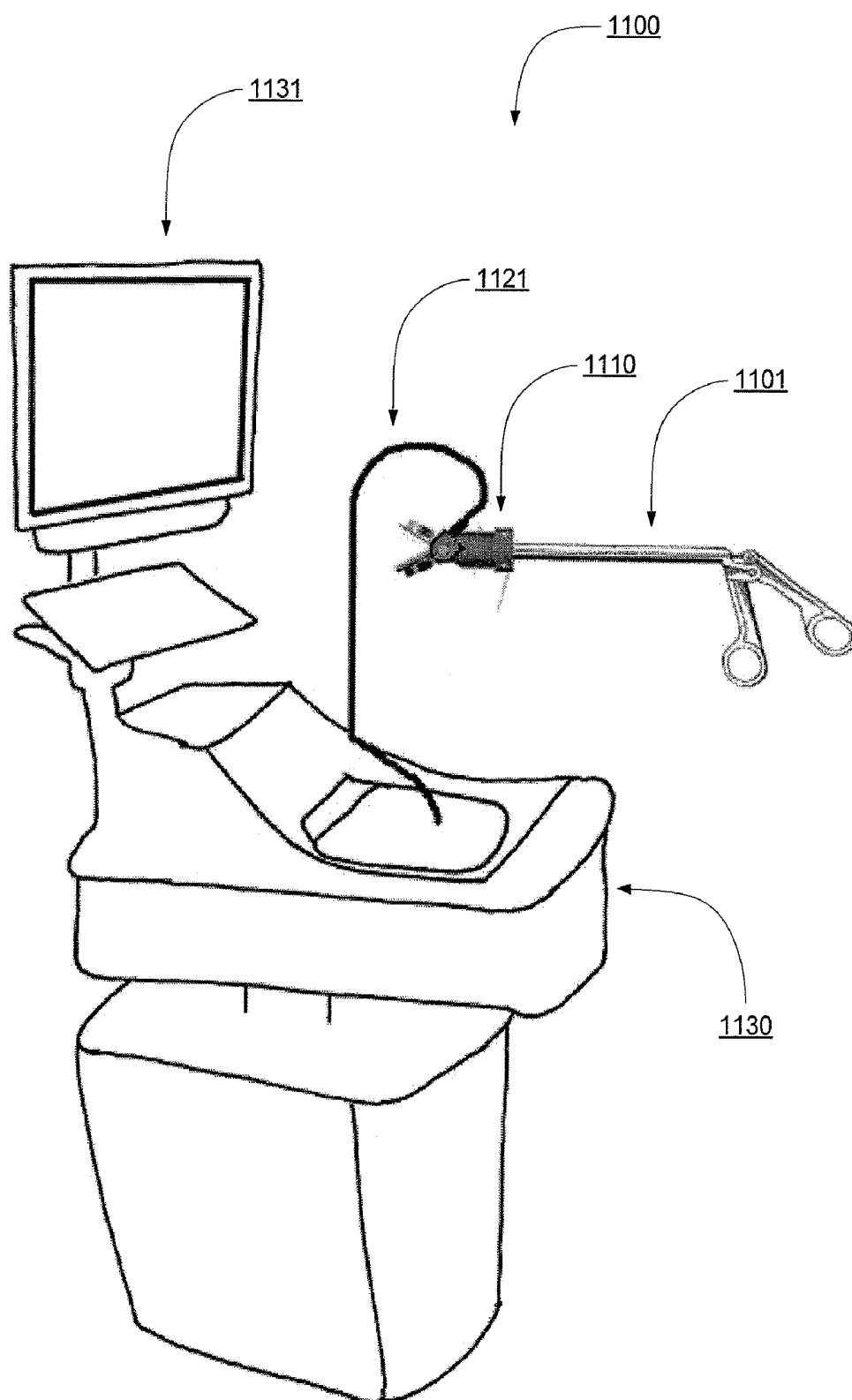


Figure 11

SYSTEMS AND METHODS FOR SENSING HAND MOTION BY MEASURING REMOTE DISPLACEMENT

FIELD OF THE INVENTION

[0001] The present invention generally relates to medical devices, and more specifically relates to systems and methods for sensing hand motion by measuring remote displacement.

BACKGROUND

[0002] Conventional medical simulations require specialized devices specific to each simulator to simulate a specific medical procedure. Rather than accepting tools designed for and used during actual surgical procedures, certain medical simulators may operate only with tools specifically designed for that medical simulator. Frequently, these simulator-specific tools only approximate the design and feel of real surgical tools, diminishing the realism and effectiveness of the medical simulation.

[0003] As one example, a medical simulator for laparoscopic surgery may use a laparoscopic tool designed for interaction with the simulator. Such a laparoscopic simulation tool may only approximate the design and operation of real laparoscopic tools. Laparoscopic surgery is performed by using tools where the action is delivered at a distance through a mechanical linkage. Thus, a need exists for systems and methods for sensing hand motion by measuring remote displacement.

SUMMARY

[0004] Embodiments of the present invention provide systems and methods for sensing hand motion by measuring remote displacement. In one embodiment, a system for sensing hand motion by measuring remote displacement comprises an apparatus comprising a first surface configured to engage a first distal member of a surgical tool, a second surface configured to engage a second distal member of the surgical tool, the second surface coupled to the first surface at a pivot point; and a sensor configured to detect a relative movement of the first surface and the second surface about the pivot point and to generate a signal corresponding to the relative movement.

[0005] In another embodiment, a method for sensing hand motion by measuring remote displacement comprises engaging a first distal member of a surgical tool at a first surface, engaging a second distal member of the laparoscopic tool at a second surface, the second surface coupled to the first surface at a pivot point; determining a relative movement of the first distal member and the second distal member; and outputting a signal based at least in part on the relative movement of the first distal member and the second distal member.

[0006] These illustrative embodiments are mentioned not to limit or define the invention, but to provide two examples to aid understanding thereof. Illustrative embodiments are discussed in the Detailed Description, and further description of the invention is provided there. Advantages offered by the various embodiments of the present invention may be further understood by examining this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention are better understood when the following Detailed Description is read with reference to the accompanying drawings, wherein:

[0008] FIG. 1 is an illustration of a surgical tool used for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0009] FIG. 2 is a top perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0010] FIGS. 3A and 3B are side perspectives of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0011] FIG. 4 is a front perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0012] FIG. 5 is a rear perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0013] FIG. 6 is a side-rear perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0014] FIG. 7 is a side perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0015] FIG. 8 is front perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0016] FIG. 9 is a block diagram of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention;

[0017] FIG. 10 is a flow diagram of a method for sensing hand motion by measuring remote displacement according to one embodiment of the present invention; and

[0018] FIG. 11 is an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0019] Embodiments of the present invention comprise systems and methods for sensing hand motion by measuring remote displacement. Systems according to the present invention may be embodied in a number of ways. Certain embodiments of the present invention may, for example, sense the motion of a laparoscopic tool through two members attached to a pivot point.

Example of a System for Sensing Hand Motion by Measuring Remote Displacement

[0020] In one illustrative embodiment of the present invention, a system such as a medical procedure simulator comprises an apparatus configured to engage a surgical tool, such as a laparoscopic tool. In the embodiment, the laparoscopic tool comprises a pair of handles or holds. The handles, at the proximal end of the laparoscopic tool, are connected to a distal end of the tool via a thin shaft. The handles are configured to manipulate a pair of members, such as scissor blades or prongs located at the distal end of the laparoscopic tool. By

engaging the handle of the laparoscopic tool a user may open and/or close the first distal member and the second distal member of the tool.

[0021] The apparatus is engaged with the laparoscopic tool by sliding the apparatus over the tool's distal end. An anchor secures the apparatus about the laparoscopic tool. The anchor comprises two spring loaded members. Each spring loaded member applies pressure about the shaft of the laparoscopic tool to keep the apparatus in place. The anchor can be configured to accept a plurality of tools, for example, by being tolerant of various diameters of laparoscopic tool shafts.

[0022] A first surface of the apparatus is configured to engage the first distal member of the laparoscopic tool, and a second surface of the apparatus is configured to engage the second distal member of the laparoscopic tool. The surfaces may engage the distal members through several means, such as through direct contact, or through an interlocking mechanism. The first surface of the apparatus and the second surface of the apparatus are coupled together at a pivot point. During operation of the laparoscopic tool, the distal members open and/or close, causing the surfaces of the apparatus to flex or contract in parallel with the distal members. The apparatus can be configured to engage a laparoscopic tool with asymmetric operation. In such an embodiment, the first surface and the second surface of the apparatus can be configured to move independently of each other, or asymmetrically. In another variation, the apparatus can be configured to engage a laparoscopic tool with symmetric operation. During symmetric operation, the first surface of the apparatus and the second surface of the apparatus may be displaced or move in unison towards or away from each other.

[0023] As the laparoscopic tool's distal members open and close, the first and second surfaces of the apparatus operate in a corresponding fashion. As the first and second surfaces open and close, one or more sensors detect the relative movement of the surfaces about the pivot point. The sensor(s) can report the relative movement of the surfaces to a processor and/or a surgical simulation device. By providing systems and methods which can be configured to accept a variety of different types and brands of surgical tools, systems and methods of the present invention may provide a more realistic surgical simulation.

[0024] This example is given to introduce the reader to the general subject matter discussed herein. The disclosure is not limited to this example. Further details regarding various embodiments for sensing hand motion by measuring remote displacement are described below

Example of a Surgical Tool

[0025] FIG. 1 is an illustration of a surgical tool used for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration shown in FIG. 1, a surgical tool used for sensing hand motion by measuring remote displacement comprises a laparoscopic tool 100. Laparoscopic tools, such as the one illustrated in FIG. 1, may be used to create incisions or grasp objects during a surgical procedure. The laparoscopic tool 100 comprises a distal end 101, a proximal end 103, and a shaft 102 connecting the distal end 101 with the proximal end 103. In other embodiments, the surgical tool used for sensing hand motion by measuring remote displacement comprises a gynecological tool, an arthroscopic tool, a surgical knife, scissors, tweezers, clamps, retractors, distractors, forceps, calipers, a surgical elevator, or a surgical suture.

The surgical tool may comprise a real surgical tool, or a proxy/substitute surgical tool, which is intended to mimic the look, feel, and/or function of a surgical tool.

[0026] At the proximal end 103, the laparoscopic tool 100 comprises a first handle 106 and a second handle 107. The handles 106, 107 may be grasped by a user and manipulated. Alternatively, a robot or mechanical device may operate the laparoscopic tool 100. At the distal end 101, the laparoscopic tool 100 comprises a first distal member 104 and a second distal member 105. Distal members 104, 105 may each comprise a blade, for example, to make a surgical incision. Alternatively, distal members 104, 105 may each comprise a grasper or a gripper. A linkage 108 extends through the shaft 102 from the proximal end 103 to the distal end 101, and mechanically connects the handles 106, 107 with the distal members 104, 105.

[0027] By manipulating the handles 106, 107, the first distal member 104 and/or the second distal member 105 may be operated. For example, compressing or flexing the second handle 107 towards the first handle 106 may cause the first distal member 104 and the second distal member 105 to compress or pivot towards each other. Releasing or opening the handles 106, 107 may cause the distal members 104, 105 to open, or pivot away from each other.

[0028] In some embodiments, the distal members 104, 105 of the laparoscopic tool 100 may operate symmetrically. That is, as the handles 106, 107 are manipulated, each distal member 104, 105 moves an equal amount. In other embodiments, the distal members 104, 105 operate asymmetrically. In one example, as the handles 106, 107 are manipulated, the first distal member 104 remains in place while the second distal member 105 moves towards or away from the first distal member 104. Movement of one or both of the handles 106, 107 may directly correspond to movement of one or both of the distal members 104, 105.

Examples of Systems for Sensing Hand Motion by Measuring Remote Displacement

[0029] FIG. 2 is a top perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 2, the system 200 comprises an apparatus 210 fitted about a surgical tool 201. The surgical tool 201 comprises a laparoscopic tool, such as the one illustrated in FIG. 1. In other embodiments, different surgical tools 201 may be used.

[0030] As illustrated in FIG. 2, the surgical tool 201 comprises a first distal member 204 and a second distal member 205. A shaft 202 connects the distal members 204, 205 with a control mechanism (not shown in FIG. 2). The control mechanism may comprise a pair of handles, such as the handles 106, 107 illustrated in FIG. 1. In other variations, the surgical tool 201 may be manipulated by other means.

[0031] The apparatus 210 is fitted about the distal end of the surgical tool 201. In one embodiment, the entire apparatus assembly may measure approximately 3 centimeters in length. In other variations, the apparatus may be longer or shorter. The apparatus 210 can be configured to minimally restrict or impede the motion or operation of the surgical tool 201. By restricting or minimizing the chance in operation of the surgical tool, users of the surgical tool equipped with the apparatus may be more immersed in a medical simulation, as the apparatus would be less noticeable to the user. As one example, the apparatus 210 may be constructed, at least in

part, of a lightweight plastic or resin material. An apparatus **210** constructed of a heavyweight material may change or impede the operation of the surgical tool **201**, for example, by impeding the motion of the distal members **204**, **205**. In contrast, an apparatus **210** constructed of lightweight materials may not impede the operation of the surgical tool, thereby increasing the effectiveness of the surgical simulation.

[0032] The apparatus **210** comprises an anchor **220** configured to fit about the shaft **202** of the surgical tool **201**, and configured to secure the apparatus **210** about the shaft **202**. As an example, the anchor **220** may be configured to slide over the distal end of the surgical tool **201**, as the distal members **204**, **205**, are contracted together. In one embodiment, the anchor **220** comprises a first anchoring surface and a second anchoring surface (not shown in FIG. 2). In another embodiment, the anchor **220** may comprise a plurality of anchoring surfaces. For example, the anchor **220** may comprise an iris mechanism comprising a plurality of anchoring surfaces. Each anchoring surface can be spring loaded, and configured to apply pressure to the shaft **202** of the surgical tool **201** to secure the apparatus **210** about the shaft **201**.

[0033] Each anchoring surface may be spring loaded. By spring-loading the anchoring surfaces, the anchoring surfaces may be better able to hold the shaft in place. In another variation, the anchoring surfaces may secure the apparatus **210** about the surgical tool **201** through other means. For example, the anchoring surfaces may comprise a material resistant to flexure. When the shaft **202** is inserted through the anchor **220**, the anchoring surfaces may naturally resist flexure.

[0034] The anchor **220** may be configured to accept a variety of different surgical tools. In one embodiment, the anchoring surfaces are configured to accept a range of diameters of surgical tools. By being tolerant of various diameters of surgical tools, a surgical simulator utilizing the apparatus **210** may be more accommodating and practical.

[0035] The apparatus **210** additionally comprises a first surface **214** and a second surface **215**. The surfaces may comprise a flat, rigid material, such as plastic or metal. The first surface **214** and the second surface **215** can be affixed to a pivot point **211**. By affixing the surfaces **214**, **215** to the pivot point **211**, the surfaces may move or pivot about the pivot point **211**.

[0036] The first surface **214** can be configured to engage the first distal member **204** of the surgical tool **201**. Additionally, the second surface **215** can be configured to engage the second distal member **205** of the surgical tool **201**. The surfaces **214**, **215** of the apparatus **210** may engage the distal members **204**, **205** of the surgical tool **201** through direct contact, such as illustrated in FIG. 2. In one variation not illustrated in FIG. 2, one or both of the surfaces **214**, **215** may slidably engage the distal members **204**, **205** through an open loop (not shown in FIG. 2).

[0037] As the surgical tool **201** is manipulated, the distal members **204**, **205** may flex or pivot about a pivot point. By engaging the distal members **204**, **205**, the surfaces **214**, **215** of the apparatus may flex or pivot in tandem with the distal members **204**, **205**. As the surfaces flex or pivot, a sensor **216** may detect relative movements of the surfaces **214**, **215**. For example, as the surfaces **214**, **215** move towards and away from each other, a sensor detects their movement about the pivot point, and generates a signal based at least in part on their movement. In one embodiment, a plurality of sensors

216 detect the relative movements of the surfaces **214**, **215**. For instance, a first sensor may detect movement of the first surface **214**, and a second sensor may detect movement of the second sensor **215**. Each of the plurality of sensors may be configured to detect movement of a surface **214**, **215** from a ground or rest position.

[0038] The surfaces **214**, **215** of the apparatus **210** may be configured to engage the surgical tool **201** without impeding the motion of the surgical tool **201**. For example, the surfaces **214**, **215** may engage the distal members **204**, **205** with little or no resistance. Thus, a user operating the surgical tool **201** while it is engaged by the apparatus **210** may experience little or substantially no difference in operation of the surgical tool **201**.

[0039] The first surface **214** may be configured to move independently of the second surface **215**. For example, as the first surface **214** pivots about the pivot point **211**, the second surface **215** may remain stationary. A sensor may be configured to detect the asymmetric movement of the first surface **214** relative to the second surface **215**, and to generate a signal based at least in part on the asymmetric movement.

[0040] The apparatus **210** further comprises a sensor **216**. The sensor **216** can be configured to detect a relative movement of the first surface **214** and the second surface **215** about the pivot point **211**. In one variation, the sensor is configured to measure the displacement of the surfaces **214**, **215** about the pivot point **211**. The sensor **216** may comprise a potentiometer. Alternatively, the sensor **216** may comprise an optical sensor, or some other type of sensor configured to detect motion. In one variation, the apparatus **210** comprises two sensors, each sensor configured to detect a relative movement of a surface. In another variation, the apparatus **210** comprises a plurality of sensors.

[0041] The sensor **216** may be configured to communicate with a processor and/or a simulation device such as a surgical simulator (not shown in FIG. 2). In one embodiment, the sensor **216** generates a signal based at least in part on the relative movement of the first surface **214** and the second surface **215**. A processor configured to receive one or more signals from the sensor(s) may be configured to process the sensor signals to determine a displacement of the surfaces.

[0042] The sensor **216** may send the signal to a simulation device through a connecting mechanism **221**. Connecting mechanism **221** may comprise, for example, a wire capable of transmitting signals. In another variation, the sensor **216** may communicate with a processor or medical simulator through a wireless connecting mechanism **221**. The processor may be configured to receive signals from the sensor based at least in part on the relative movement of the first surface **204** and the second surface **205** about the pivot point **211**.

[0043] The apparatus **210** may further comprise one or more actuators (not shown in FIG. 2) configured to provide vibrotactile feedback to the surgical tool **201**. The actuators may be in communication with a processor or a simulation device, such as a laparoscopic surgical simulator. As the sensor **216** detects relative movement of the first surface **214** and the second surface **215**, the simulation device may transmit an actuator signal to the actuator. The actuator signal may cause one or more actuators to provide vibrotactile feedback to the surgical tool **201**.

[0044] FIGS. 3A and 3B are side perspectives of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. FIG. 3A illustrates one side perspective of

a system for sensing hand motion by measuring remote displacement. FIG. 3B illustrates the opposite side perspective of the system for sensing hand motion by measuring remote displacement.

[0045] According to the illustrations in FIG. 3A and FIG. 3B, the system 300 comprises an apparatus 310 fitted about a surgical tool 301. The surgical tool comprises a first distal member 304 and a second distal member 305. A shaft 302 connects the distal members 304, 305 with a control mechanism, such as a pair of handles (not shown in FIGS. 3A, 3B).

[0046] The apparatus 310 for measuring remote displacement comprises a first surface 314 and a second surface 315. As shown in FIGS. 3A and 3B, the first surface 314 is engaging the first distal member 304, and the second surface 315 is engaging the second distal member 305. As shown in FIGS. 3A and 3B, the surfaces 314, 315 engage the distal members 304, 305 through direct contact. One or more spring mechanisms (not shown in FIGS. 3A and 3B) may apply pressure on one or both surfaces 314, 315 for reliably engaging the distal members 304, 305.

[0047] As shown in FIG. 3B, the apparatus 310 comprises a sensor 316. The sensor 316 is configured to detect a relative movement of the first surface 314 and the second surface 315 about the pivot point 311. The sensor 316 is also configured to generate a signal based at least in part on the relative movement of the first surface 314 and the second surface 315.

[0048] The sensor 316 is in communication with a processor 320. The processor is configured to receive a signal from the sensor. For example, the processor can be configured to receive signals from the sensor indicating relative movement of the surfaces 314, 315 about the pivot point. The processor may be in communication with a medical simulator (not shown in FIGS. 3A and 3B).

[0049] FIG. 4 is a front perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 4, the system 400 comprises an apparatus 410 for measuring remote displacement. The apparatus 410 is fitted about a surgical tool. As shown in FIG. 4, the surgical tool comprises a first distal member 404 and a second distal member 405. A shaft (not shown) connects the distal members 404, 405 with a control mechanism, such as a pair of handles (not shown in FIG. 4). A user may manipulate the control mechanism, causing the distal members 404, 405 to expand and contract, or move towards or away from each other, respectively. As shown in FIG. 4, the distal members 404, 405 are shown expanded, away from each other.

[0050] The apparatus 410 for measuring remote displacement comprises a first surface 414 and a second surface 415. As shown in FIG. 4, the first surface 414 is engaging the first distal member 404, and the second surface 415 is engaging the second distal member 405. In the embodiment shown in FIG. 4, the surfaces 414, 415 are engaging the distal members 404, 405 through direct contact. One or more spring mechanisms (not shown in FIG. 4) may apply pressure on one or both surfaces 414, 415 for reliably engaging the distal members 404, 405.

[0051] FIG. 5 is a rear perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 5, the system 500 comprises an apparatus for measuring remote displacement 510. The apparatus 510 is fitted about a surgical tool. As

shown in FIG. 5, the surgical tool comprises a first distal member 504 and a second distal member 505. A shaft 502 connects the distal members 504, 505 with a control mechanism, such as a pair of handles (not shown in FIG. 5). A user may manipulate the control mechanism, causing the distal members 504, 505 to expand and contract, or move towards or away from each other, respectively. The apparatus 510 comprises a first surface 514 and a second surface 515. As shown in FIG. 5, the first surface 514 is engaging the first distal member 504, and the second surface 515 is engaging the second distal member 505.

[0052] The apparatus 510 additionally comprises an anchor 520 fitted about the surgical tool. The anchor 520 can fit about the surgical tool by sliding over the distal end of the surgical tool. The anchor 520 is configured to secure the apparatus 510 about the surgical tool.

[0053] The anchor 520 comprises a first anchoring surface 516 and a second anchoring surface 517. In other embodiments, the anchor 520 may comprise a plurality of anchoring surfaces 516, 517 are spring loaded. The first anchoring surface 516 is engaged by a first spring 518, and the second anchoring surface 517 is engaged by a second spring 519. Each spring loaded anchoring surface 516, 517 applies pressure about the shaft 502 of the surgical tool to keep the apparatus 510 in place. The anchor 520 can be configured to accept a plurality of tools, for example, by being tolerant of various diameters of laparoscopic tool shafts. In one variation, the anchoring members 516, 517 flexibly engage a plurality of surgical tools, each surgical tool having a different diameter.

[0054] FIG. 6 is a side-rear perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 6, the system 600 comprises an apparatus for measuring remote displacement 610. The apparatus 610 is fitted about the shaft 602 of a surgical tool. The apparatus 610 comprises a first surface 614 and a second surface 615. The second surface 615 is coupled to the first surface 614 at a pivot point 611. Each of the surfaces 614, 615 engages a distal member (not shown in FIG. 6) of the surgical tool.

[0055] The apparatus 610 additionally comprises an anchor 620 fitted about the surgical tool. The anchor 620 can fit about the surgical tool by sliding over the distal end of the surgical tool. The anchor 620 is configured to secure the apparatus 610 about the surgical tool.

[0056] The anchor 620 comprises a first anchoring surface 616 and a second anchoring surface 617. As shown in FIG. 6, each of the anchoring surfaces 616, 617 are spring loaded. The first anchoring surface 616 is engaged by a first spring 618, and the second anchoring surface 617 is engaged by a second spring 619. Each spring loaded anchoring surface 616, 617 applies pressure about the shaft 602 of the surgical tool to keep the apparatus 610 in place.

[0057] FIG. 7 is a side perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 7, the system 700 comprises an apparatus 710 fitted about the distal end and shaft 702 of a surgical tool. The surgical tool further comprises a first distal member 704 and a second distal member 705. The shaft 702 connects the distal members 704, 705 with a control mechanism, such as a pair of handles (not shown in FIG. 7).

[0058] The apparatus 710 for measuring remote displacement comprises a first surface 714 and a second surface 715. The second surface 715 is coupled to the first surface 714 at a pivot point 711. Each of the surfaces 714, 715 engages one of the distal members 704, 705. As shown in FIG. 7, the first surface 714 is engaging the first distal member 704 through direct contact. In contrast, the second surface 715 is slidably engaging the second distal member 705. For example, the second distal member 705 may slide through a loop or gap in the second surface 715, such that when the second distal member 705 moves, the second surface 715 moves in a corresponding fashion.

[0059] FIG. 8 is a front perspective of an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 8, the system 800 comprises an apparatus 810 fitted about the distal end of a surgical tool. The surgical tool comprises a first distal member 804 and a second distal member 805. A shaft (not shown in FIG. 8) of the surgical tool connects the distal members 804, 805 with a control mechanism, such as a pair of handles (not shown in FIG. 8).

[0060] The apparatus 810 for measuring remote displacement comprises a first surface 814 and a second surface 815. The second surface 815 is coupled to the first surface 814 at a pivot point 811. Each of the surfaces 814, 815 engages one of the distal members 804, 805. As shown in FIG. 8, the first surface 814 is engaging the first distal member 804 through direct contact. In contrast, the second surface 815 is slidably engaging the second distal member 805. In the illustration, the second distal member 805 is fitted through a gap in the second surface 815, such that when the second distal member 805 moves, the second surface 815 moves in a corresponding fashion.

[0061] FIG. 9 is a block diagram of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. According to the illustration in FIG. 9, the apparatus 900 comprises a first surface 902 and a second surface 904. Each of the surfaces 902, 904, is configured to engage a distal member of a surgical tool.

[0062] The apparatus 900 also comprises a sensor 906. The sensor 906 is configured to detect a relative movement of the first surface 902 and the second surface 904 about a pivot point. In one variation, the sensor comprises an optical sensor configured to measure the movement of the surfaces 902, 904. In other variations, sensor 906 may comprise an optical encoder, electrical encoder, magnetic encoder, or a hall effect sensor.

[0063] The sensor 906 is in communication with a processor 908. The processor 908 can be configured to receive a signal from the sensor. The processor 908 may be in communication with a medical simulator (not shown in FIG. 9).

[0064] The processor 908 is in communication with an actuator 910. The actuator can be configured to provide vibrotactile feedback to the apparatus 900. In one variation, the sensor detects a relative movement of the first surface 902 and the second surface 904, as a user operates a surgical tool engaged by the apparatus 900. The sensor 906 sends a signal based at least in part on the relative movement of the surfaces 902, 904 to the processor 908. The processor 908 subsequently sends an actuator signal to the actuator 910 based at least in part on the relative movement of the surfaces 902, 904. The actuator signal causes the actuator 910 to provide

vibrotactile feedback to the apparatus 900, for example, by vibrating the surfaces 902, 904.

[0065] FIG. 10 is a flow diagram of a method for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. In step 1002, the method comprises the step of engaging a first distal member of a laparoscopic tool at a first surface. In step 1004, the method comprises the step of engaging a second distal member of the laparoscopic tool at a second surface. The first surface and the second surface may be coupled at a pivot point.

[0066] Step 1006 comprises the step of determining a relative movement of the first surface and the second surface. A sensor, such as an optical sensor or a potentiometer, may determine the relative movement of the first surface and the second surface. Because the first distal member is engaged by the first surface 1002, and the second distal member is engaged by the second surface 1004, the relative movement of the first surface and the second surface may directly correspond to the relative movement of the first distal member and the second distal member.

[0067] Finally, step 1008 comprises the step of outputting a signal based at least in part on the relative movement of the first surface and the second surface. For example, a sensor 906 may output a signal to a processor 908.

[0068] FIG. 11 is an illustration of a system for sensing hand motion by measuring remote displacement according to one embodiment of the present invention. The system 1100 in FIG. 11 comprises a surgical tool 1101, such as a laparoscopic tool. As shown in FIG. 11, the laparoscopic tool is engaged by an apparatus 1110 for sensing hand motion by measuring remote displacement.

[0069] The apparatus 1110 comprises a connecting mechanism 1121. As illustrated in FIG. 11, the connecting mechanism is a wire capable of transmitting signals to and from the apparatus 1110. For example, the apparatus 1110 may comprise a sensor (not shown in FIG. 11) configured to detect a relative movement of a first surface of the apparatus and a second surface of the apparatus engaging distal members of the laparoscopic tool 1101. The sensor may be configured to transmit signals via the connecting mechanism 1121 to a processor (not shown in FIG. 11). In another variation, the apparatus 1110 may comprise a wireless connecting mechanism.

[0070] As shown in FIG. 11, the apparatus 1110 is in communication with a medical simulator 1130. The medical simulator may comprise a processor (not shown in FIG. 11) and a display 1131. The display 1131 may be configured to show a simulation of a medical procedure, such as a laparoscopic surgery.

[0071] Embodiments of systems and methods for sensing hand motion by measuring remote displacement may provide various advantages over current medical simulators. In one embodiment, a system allows a medical simulator to track a user's manipulation of a surgical tool by measuring the displacement of the tool at the far end, or distal end, of the surgical tool. An apparatus may be attached to any real surgical tool. As one or both jaws, or distal members, of the surgical tool moves, each jaw independently pushes on a spring-loaded lever, or surface. A sensor can be configured to track the relative motion of each surface or lever moving in concert with the jaws.

[0072] Systems and methods for sensing hand motion by measuring remote displacement may be configured to operate

with a variety of surgical tools with various operating parameters. For example, a system may be configured to accept a plurality of tools with different geometries, such as shaft diameters or distal member shapes or sizes. By measuring either symmetrical or asymmetrical movement of a surgical tool's distal members, and by being diameter-tolerant, the apparatus may be used with a wide variety of surgical tools. [0073] In some embodiments, the sensation of using the surgical tool with the apparatus for sensing hand motion by measuring remote displacement is similar to or the same as using the surgical tool without the apparatus attached. For example, the apparatus may be lightweight, and cause little or no resistance on the jaws of the surgical tool. In some instances, the apparatus works passively, with little or no physical encumbrance to the surgical tool. The passive operation of the apparatus may be facilitated by spring-loaded members which engage each jaw of the surgical tool.

General

[0074] The foregoing description of the embodiments of the invention has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Numerous modifications and adaptations thereof will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

That which is claimed:

1. An apparatus, comprising:
 - a first surface configured to engage a first distal member of a surgical tool,
 - a second surface configured to engage a second distal member of the surgical tool, the second surface coupled to the first surface at a pivot point; and
 - a sensor configured to detect a relative movement of the first surface and the second surface about the pivot point and to generate a signal based at least in part on the relative movement.
2. The apparatus of claim 1, further comprising a processor in communication with the sensor and configured to receive the signal from the sensor.
3. The apparatus of claim 1, further comprising a flexure to apply a force about the pivot point.
4. The apparatus of claim 1, further comprising an anchor configured to secure the apparatus about a shaft of the surgical tool.
5. The apparatus of claim 4, wherein the anchor comprises a first anchoring surface and a second anchoring surface.
6. The apparatus of claim 5, wherein the first anchoring surface and the second anchoring surface are spring loaded.
7. The apparatus of claim 6, wherein the first anchoring surface and the second anchoring surface are configured to accept a plurality of surgical tools, each of the plurality of surgical tools having a different diameter.
8. The apparatus of claim 1, further comprising an actuator.
9. The apparatus of claim 1, wherein the surgical tool is configured to operate asymmetrically.
10. The apparatus of claim 1, wherein the surgical tool comprises a laparoscopic tool, a gynecological tool, forceps, or scissors.

11. The apparatus of claim 1, wherein the first distal member and the second distal member are configured to move symmetrically.

12. The apparatus of claim 1, wherein the first distal member and the second distal member are configured to move asymmetrically.

13. The apparatus of claim 1, wherein the sensor comprises a potentiometer, an optical encoder, electrical encoder, magnetic encoder, or a hall effect sensor.

14. The apparatus of claim 1, wherein the sensor is configured to communicate with a simulation device.

15. The apparatus of claim 1, wherein the apparatus is configured to minimally impede the operation of the surgical tool.

16. A method, comprising:

engaging a first distal member of a surgical tool at a first surface;

engaging a second distal member of the surgical tool at a second surface, the second surface coupled to the first surface at a pivot point;

determining a relative movement of the first surface and the second surface; and

outputting a signal based at least in part on the relative movement of the first surface and the second surface.

17. The method of claim 16, further comprising:

providing haptic feedback to the laparoscopic tool based at least in part on the signal.

18. The method of claim 16, further comprising:

securing an apparatus around the laparoscopic tool, the apparatus comprising the first surface, the second surface, and a sensor configured to determine the relative movement of the first distal member and the second distal member.

19. An apparatus configured to detect the relative motion of a laparoscopic tool, the apparatus comprising:

an assembly, comprising

an anchor comprising a top surface and a bottom surface, the top surface coupled to a first spring, the bottom surface coupled to a second spring, the anchor configured to secure a shaft of the laparoscopic tool;

a first surface configured to engage a first distal member of the laparoscopic tool,

a second surface configured to engage a second distal member of the laparoscopic tool, the first surface coupled to the second surface at a pivot point,

a sensor configured to measure the relative movement of the first surface and the second surface and transmit a movement signal based at least in part on the relative movement of the top surface and the bottom surface to a laparoscopic simulator device;

a processor in communication with the sensor and configured to receive the movement signal from the sensor and transmit an actuator signal based at least in part on the movement signal; and

an actuator in communication with the sensor and configured to receive the actuator signal and provide vibrotactile feedback to the assembly, the vibrotactile feedback based at least in part on the relative movement of the first surface and the second surface.

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专利名称(译)	通过测量远程位移来感测手部运动的系统和方法		
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摘要(译)

公开了通过测量远程位移来感测手部运动的系统和方法。例如，一个公开的装置包括第一表面和第二表面，第一表面构造成为外科工具的第一远侧构件，第二表面构造成为外科工具的第二远侧构件，第二表面在枢转点处联接到第一表面。该装置还包括传感器，该传感器被配置为检测第一表面和第二表面绕枢轴点的相对运动并且至少部分地基于相对运动产生信号。

