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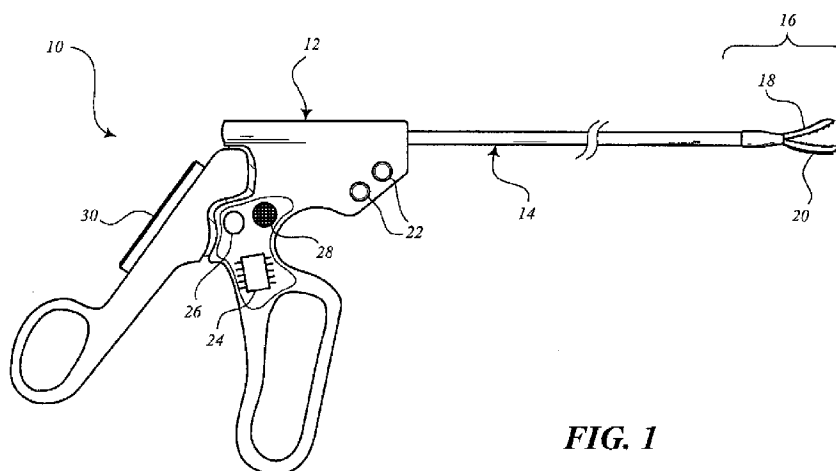
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(54) **Title:** TOOL HAVING MULTIPLE FEEDBACK DEVICES



**FIG. 1**

(57) **Abstract:** Disclosed herein are systems and methods for managing how signals, which are sensed on a tool, are presented to an operator of the tool. According to one example of a method for managing signals, the method comprises allowing an operator to manipulate a tool having a plurality of output mechanisms mounted thereon. The method also includes sensing a property of an object located near or adjacent to a distal portion of the tool and processing the sensed property to obtain one or more output signals. Furthermore, the method includes applying the one or more output signals to one or more of the output mechanisms.

## **TOOL HAVING MULTIPLE FEEDBACK DEVICES**

### **TECHNICAL FIELD**

**[0001]** The embodiments of the present disclosure generally relate to hand tools and more particularly relate to sensing a property of an object in the vicinity of a hand tool and displaying the property in one or more output modes.

### **BACKGROUND**

**[0002]** As opposed to open surgery in which a surgeon cuts a relatively large incision in the skin of a patient for accessing internal organs, minimally invasive surgical procedures are performed by making relatively small incisions and then inserting tools through the incisions to access the organs. Minimally invasive surgery usually results in shorter hospitalization times, reduced therapy requirements, less pain, less scarring, and fewer complications.

**[0003]** During minimally invasive surgery, the surgeon can introduce a miniature camera through an incision. The camera transmits images to a visual display, allowing the surgeon to see the internal organs and tissues and to see the effect of other minimally invasive tools on the organs and tissues. In this way, the surgeon is able to perform laparoscopic surgery, dissection, cauterization, endoscopy, telesurgery, etc. Compared to open surgery, however, minimally invasive surgery can present limitations regarding the surgeon's ability to see and feel the patient's organs and tissues.

### **SUMMARY**

**[0004]** The present disclosure describes a number of embodiments of systems and methods for managing how sensed signals are provided to an operator of a tool, which includes a sensor for sensing the signals. In one embodiment, for example, a method for managing signals includes allowing an operator to manipulate a tool having a plurality of output mechanisms mounted thereon. The method also includes sensing a property of an object located near or adjacent to a distal portion of the tool and processing the sensed property to obtain one or more

output signals. The method also includes applying the one or more output signals to one or more of the output mechanisms.

[0005] The embodiments described in the present disclosure may include additional features and advantages, which may not necessarily be expressly disclosed herein but will be apparent to one of ordinary skill in the art upon examination of the following detailed description and accompanying drawings. It is intended that these additional features and advantages be included and encompassed within the present disclosure.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0006] The components of the following figures are illustrated to emphasize the general principles of the present disclosure and are not necessarily drawn to scale. Reference characters designating corresponding components are repeated as necessary throughout the figures for the sake of consistency and clarity.

[0007] FIG. 1 is a diagram illustrating a side view of a surgical tool according to one embodiment.

[0008] FIG. 2 is a diagram illustrating a rear perspective view of a surgical tool having a level meter mounted thereon, according to one embodiment.

[0009] FIG. 3 is a diagram illustrating a rear perspective view of a surgical tool having an LCD screen mounted thereon, according to one embodiment.

[0010] FIG. 4 is a diagram illustrating a side view of a surgical tool having a device for providing visual and haptic output to an operator, according to one embodiment.

[0011] FIG. 5 is a diagram illustrating a side view of a surgical tool having a rotary device, according to one embodiment.

[0012] FIG. 6 is a diagram illustrating a side view of a surgical tool having haptic actuating devices formed in the handle thereof, according to one embodiment.

[0013] FIG. 7 is a block diagram of a system for communicating sensed properties to an operator, according to one embodiment.

[0014] FIG. 8 is a flow diagram illustrating a method for controlling signals sensed by a sensor mounted on a tool, according to one embodiment.

#### DETAILED DESCRIPTION

[0015] Although minimally invasive surgical procedures involving small incisions include many advantages over open surgery, minimally invasive surgery can still create challenges to a surgeon. For example, the surgeon must typically rely on a camera to view the patient's internal organs and see how the movement and operation of the tools affects the organs. To enhance the surgeon's experience, feedback can be provided to the surgeon to communicate information about how the body of the patient reacts to the tools. According to the teaching of the present disclosure, output can be provided to the surgeon in multiple ways, e.g., visually, audibly, tactilely, etc. Information regarding the status of feedback devices can also be provided to the surgeon as well.

[0016] The present disclosure describes embodiments that include any type of tools that can be manipulated by an operator. More particularly, the tools described in the present disclosure include a handle portion that mechanically controls a distal portion of the tool. Mounted on the distal portion are one or more sensors configured to sense a parameter of an object that interacts with the tool. The sensed signals can be processed to obtain stimulation signals designed to be provided to one or more output mechanisms, such as, for example, haptic actuation devices, vibrotactile feedback devices, kinesthetic feedback devices, visual displays, speakers or other audio devices, etc.

[0017] Although many of the examples described in the embodiments of the present disclosure relate to surgical tools, such as minimally invasive surgical tools, it should be understood that the present disclosure also encompasses other types of tools as well. In addition, although many of examples herein relate to surgical patients and how the organs and tissues of the patient interact with the surgical tools, it should also be understood that the present disclosure may also refer to other objects that are intended to interact with or react to the operations of the respective tools. Other features and advantages will be apparent to one of

ordinary skill in the art upon reading and understanding the general principles of the present disclosure and are intended to be included herein.

**[0018]** FIG. 1 is a diagram illustrating an embodiment of a surgical tool 10. In this diagram, surgical tool 10 is shown as a laparoscopic tool, which is configured to be inserted through a small incision in the abdomen of a patient. Surgical tool 10 in this embodiment includes a handle 12, a shaft 14, and a distal portion 16. Shaft 14 is designed to connect handle 12 to distal portion 16 and to communicate mechanical actions of handle 12 to distal portion 16. Shaft 14 is further designed to communicate electrical signals from distal portion 16 back to handle 12 as explained in more detail below.

**[0019]** According to the embodiment of FIG. 1, distal portion 16 includes a tip 18 and a sensing device 20 formed on tip 18. As shown, tip 18 is a grasper. However, it should be understood that distal portion 16 may include any suitable type of tip having any suitable functionality. Also, in other alternative embodiments, sensing device 20 may be connected to any part of distal portion 16 or even other parts of tip 18. According to some examples of the embodiment of FIG. 1, shaft 14 may be about 20 cm to 30 cm in length and tip 18 may be about 10 mm to 15 mm in length.

**[0020]** According to the embodiment of FIG. 1, handle portion 12 of surgical tool 10 further includes one or more buttons 22. Buttons 22 can be configured using any suitable mechanism for allowing an operator to control the nature of the feedback that is provided to the operator. Buttons 22 may include devices for allowing certain levels to be adjusted or certain selections to be made regarding the output presented to the operator. In some embodiments, buttons 22 may be configured as switches, such as momentary toggle switches, allowing an operator to select different ways in which sensor information is mapped or provided to respective output devices. Buttons 22 can be implemented as a rocker switch or as a one-dimensional control surface.

**[0021]** Handle portion 12 also includes a processing device 24, haptic actuator 26, and a speaker 28, which are shown through a cut out in handle portion 12. Processing device 24, haptic actuator 26, and speaker 28 can be mounted on a printed circuit board (not shown), which includes circuitry for electrically

coupling the components. The circuitry on the printed circuit board may include any suitable amplification and attenuation type circuitry, power sources for providing and regulating power to each components, and other circuitry for proper operation of processing device 24 and other components as would be understood by one of ordinary skill in the art. In some embodiments, haptic actuator 26 can be implemented as an inertial actuator to provide vibrotactile feedback to the operator. Haptic actuator 26 may include an eccentric rotating mass (“ERM”) actuator, linear resonant actuator (“LRA”), piezoelectric actuator, shape memory alloy, electro-active polymer, or other suitable type of actuating device.

**[0022]** In this embodiment of FIG. 1, handle portion 12 also supports a level meter 30. As illustrated, level meter 30 is mounted on a back section of handle portion 12, which is designed for normal conformity with the operator’s thumb. Level meter 30 may be a visual feedback device to show certain levels that can be adjusted by the operator. For example, by using buttons 22, the operator can generally adjust how signals sensed by sensing device 20 are processed and presented to the operator. According to one function of buttons 22, the operator can enable or disable one or more output mechanisms by controlling whether or not output signals based on the sensed signals are provided to the respective output devices. Another function of buttons 22 includes the ability to enable one or more output mechanisms. According to FIG. 1, the output mechanisms can include at least haptic actuator 26, speaker 28, and level meter 30. In this regard, the operator can control if and how sensed signals are presented in a visual, auditory, and/or haptic fashion.

**[0023]** The different output mechanisms may be used to cooperatively communicate a single property. In some embodiments, however, they can represent distinct components of the processed sensor signals or other parameters. In some cases, one or more of the output mechanisms may be configured to provide both sensor signal information and adjustment level information, depending on the particular application.

[0024] Furthermore, buttons 22 can be used to adjust the level, intensity, or amplitude at which the output mechanisms provide the respective output. For example, the operator may wish to disable haptic actuator 26, but enable speaker 28 and have its volume turned down low.

[0025] By manipulating handle 12, an operator can insert distal portion 16 into the abdomen of the patient and control tip 18 of distal portion 16. When distal portion 16 is inserted, the surgeon can further manipulate handle 12 to control the location and orientation of tip 18 such that sensing device 20 is able to contact certain regions of the patient. Sensing device 20 may include one or more sensors each configured to measure or test any desired parameter of the patient, such as pulse, for example. In some embodiments in which sensing device 20 does not necessarily need to contact a particular region of the patient, tip 18 can be controlled to position sensing device 20 to accomplish certain contactless sensing functions.

[0026] Sensing device 20 can be configured to sense any suitable property of the object under test. For instance, sensing device 20 can be configured as pressure sensors using resistive or capacitive pressure sensing technologies. Alternatively, sensing device 20 can include strain gauges, piezoelectric sensors, stiffness sensors, etc. As strain gauges, sensing device 20 can provide additional information about contact force to finely tune a generally coarse measurement of force. As piezoelectric sensors, sensing devices 20 can generate ultrasound signals that reflect off portions of the object. In this case, echo signals can be detected by sensing device 20 to determine the location of objects. Sensing device 20 can also be configured as stiffness sensors that can detect nodules, e.g., tumors, or other stiff regions.

[0027] The features illustrated and described with respect to FIG. 1 may also be incorporated within the embodiments shown with respect to FIGS. 2-6 as described below. However, for the sake of brevity, many features shown in some drawings may not be shown in other drawings. Also, the description of similar elements in different drawings are not repeated. It should be appreciated, however, that although one or more embodiments may not include features described with respect to other embodiments, some or all of the features may still

be included therein as would be recognized from an understanding of the present disclosure.

**[0028]** FIG. 2 is a diagram showing an embodiment of a surgical tool 40 from a rear perspective. In this diagram, only a handle portion 42 and a part of a shaft 44 are shown of surgical tool 40, which may further include other features, such as a sensing device at a distal end. On a back region of handle portion 42, surgical tool 40 in this embodiment includes a level meter 46. Level meter 46 may include the same functionality as level meter 30 shown in FIG. 1. Level meter 46 can be configured to display any type of visual information to the operator. In particular, level meter 46 may be designed, for example, to display values, levels, and/or percentages of properties of the object being sensed by a distal sensor.

**[0029]** Level meter 46 may be an interactive control surface allowing the user to adjust the properties of the output mechanisms. Level meter 46 can receive touch information from the user to make adjustments. Also, level meter 46 can display status information of one or more output mechanisms mounted on surgical tool 40. In this regard, the status information can include whether a respective output mechanism is enable or disabled, the level of intensity, strength, or magnitude of the signal supplied to the respective output mechanism, or other parameters of the respective output mechanisms. Regarding parameters with respect to visual display devices, for example, certain picture quality parameters can be adjusted. Regarding parameters with respect to audio devices, for example, frequency, fade time, and other auditory parameters can be adjusted. Regarding parameters with respect to haptic actuating devices, for example, frequency, intensity, and other various haptic parameters can be adjusted.

**[0030]** FIG. 3 is a diagram showing an embodiment of a surgical tool 50 from a rear perspective view. In this diagram, only a handle portion 52 and a part of a shaft 54 are shown of surgical tool 50, which may include other features, such as a sensing device at a distal end thereof. On a back region of handle portion 52, surgical tool in this embodiment includes a liquid crystal display (LCD) screen 56. LCD screen 56 may be used to display visual information regarding the object sensed at a distal end of surgical tool 50. In some embodiments, the sensor at the distal end may contain a camera or other type of



image capture device. In this case, images can be presented on LCD screen 56 to assist the surgeon to position the tool as needed. LCD screen 56 may also be configured to show ultrasound, x-ray, or other types of radiation-based image information.

**[0031]** LCD screen 56 can include a touchscreen, which can be configured to present information, e.g., visual information, to the operator. Also, the touchscreen can also be configured to sense when the operator presses certain portions of the touchscreen. In this way, the touchscreen can act as a touchable user interface with graphical presentation capabilities. In some embodiments, LCD screen 56 may be designed with a surface that changes shape or size based on signals being sensed. For example, the surface of LCD screen 56 may be able to adjust its topology to provide an indication of the topology or other feature of the object being sensed.

**[0032]** LCD screen 56 can include supplemental information, which may depend on the context of the particular surgical procedure being performed. Information may include, for example, pre-operative information, intra-operative information, radiology information, etc. LCD screen 56 may include a graphical user device that enables the surgeon to select different feedback profiles, adjust sensor behavior, modify supplemental information, etc.

**[0033]** LCD screen 56 may also include a control slider device 58, which can be designed to allow the operator to make adjustments to the image or contour information provided on LCD screen 56. In other embodiments, control slider device 58 may instead be configured using other types of control devices, such as buttons, switches, etc., for controlling image information.

**[0034]** FIG. 4 is a diagram showing an embodiment of a surgical tool 60 from a side view. This embodiment and other embodiments illustrated herein are particularly implemented for right-handed surgeons. It should be understood, however, that a reversed or mirror-image implementation can be obtained for use by left-handed surgeons. In this diagram, only a handle portion 62 and part of a shaft 64 are shown of surgical tool 60, which may include other features, such as a sensing device at a distal portion thereof. In this embodiment, handle portion 62 supports a display device 66. Display device 66 may be configured to provide any

type of indication of properties of the object under test. For example, various properties can be sensed by one or more distal sensors or can result from different algorithmic applications during processing of sensed signals.

[0035] In the embodiment of FIG. 4, display device 66 provides information about pulse, lumen, and stiffness of the object. For example, pulse indication refers to a pulse of a blood vessel of a patient when this vital statistic is measured. The lumen indication refers to the presence or absence of a hollow tissue structure (lumen) such as a ureter, bile duct, or the like. The stiffness indication refers to the stiffness of an organ or tissues in contact with a sensor at the distal end of surgical tool 60.

[0036] Display device 66 can provide indication of particular parameters by the use of bar indicators 68, where the length of the bar of each respective bar indicator 68 represents an intensity or level of the respective parameter. Bar indicators 68 of display device 66 can be configured to provide output information both visually and haptically. For example, since display device 66 is positioned on the side of handle portion 62, the operator may be able to look at the side of surgical tool 60 during use to see display device 66. In addition, the index finger of the operator can be placed on the surface of display device 66 to haptically sense display device 66. In this respect, bar indicator 68 includes any suitable haptic output device, shape changing device, etc., to communicate the particular information to the operator using the sense of touch. Therefore, the operator can feel the length of bar indicators 68 to receive the needed feedback signals as needed, even without visually observing display device 66.

[0037] FIG. 5 is a diagram showing an embodiment of a surgical tool 70 from a side view. In this diagram, only a handle portion 72 and part of a shaft 74 are shown of surgical tool 70, which may include other features, such as a sensing device at a distal portion thereof. Handle portion 72, according to this embodiment, includes, among other things, a rotary device 76, which can be used as a "roll" control device. Rotary device 76 is connected to shaft 74 and, when rotated by operator, is configured to rotate shaft 74 about its axis. Likewise, a sensor connected to a distal portion of surgical tool 70 rotates in response to rotation of rotary device 76. In this way, the operator can control the positioning

of the sensor to pick up various signals from different sensed regions of the patient.

[0038] In this embodiment, vibrotactile, haptic, kinesthetic, and/or resistive feedback can be incorporated into rotary device 76 to indicate directly certain information through rotary device 76 itself. According to one example, a vibrotactile actuator may vibrate rotary device 76 at an amplitude based on the stiffness of the region of the patient being sensed. In another example, a sensor can be mounted on a perpendicular face of the shaft axis or distal end and oriented toward the side. Using the roll control, the sensor sweeps around the axis to observe the surrounding tissue and identify vasculature, tumor masses, etc., using visual sensor, stiffness sensor, or other suitable sensors.

[0039] FIG. 6 is a diagram showing an embodiment of a surgical tool 80 from a side view. In this diagram, only a handle portion 82 and part of a shaft 84 are shown of surgical tool 80, which may include other features, such as a sensing device at a distal portion thereof. In this embodiment, surgical tool 80 includes haptic actuating devices 86 incorporated in the handle portion 82 for providing haptic effects to the fingers and thumb of a hand of the surgeon. Haptic actuating devices 86 may be configured to provide feedback signals based on signals sensed at the distal portion of surgical tool 80. Haptic actuating devices 86 may include ERM actuators, LRAs, shape memory alloys, electromagnetic motors, electro-active polymers that deform in response to signals, mechanism for changing stiffness, vibrotactile actuators, inertial actuators, piezoelectric actuators, etc. In one example, a grasping characteristic can be used to convey contact force, pressure, etc., on haptic actuating devices 86.

[0040] Haptic actuating devices 86 may be able to sense pressure applied by the user. In response to the pressure, haptic actuating devices 86 may be configured to provide an alert that the user may be squeezing handle portion 82 too hard or too soft. Haptic actuating devices 86 may also be configured to communicate sensed information to the user.

[0041] FIG. 7 is a block diagram illustrating an embodiment of a system 94 for controlling how sensed signals are provided to an operator. In this embodiment, system 94 includes one or more sensors 96, a processing device 98,

one or more haptic actuators 100, one or more visual displays 102, and one or more audio devices 104. Sensor 96 may be positioned on a portion of a tool, e.g., a distal end of a tool used for probing an object. Sensor 96 is configured to include any type of sensing mechanisms to sense any suitable characteristic of the object.

**[0042]** The sensed information from each of the one or more sensors 96 is communicated to processing device 98, which is configured to process the information according to specific algorithms and operator selections. Processing device 98, for example, may correspond to processing device 24 shown in FIG. 1. Depending on the type of sensing mechanisms of sensors 96 and the type of properties being measured, the algorithms of processing device 98 can determine various characteristics of the object. Processing device 98 also takes into account operator input regarding enabling or disabling one or more output mechanisms, adjusting of levels of the one or more output mechanisms, etc. Processing device 98 may then communicate the processed information to one or more of haptic actuator 100, visual display 102, and audio device 104 according to which ones of these output mechanisms are enabled and how they are controlled to provide their respective outputs. Haptic actuator 100, visual display 102, and audio device 104 represent the output mechanisms that are designed to present the sensor information to the operator.

**[0043]** Processing device 98 may be a general-purpose or specific-purpose processor or microcontroller for processing the signals detected by sensor 96. In some embodiments, processing device 98 may include a plurality of processors for performing different functions with respect to system 94. In some embodiments, processing device 98 may be associated with a memory device (not shown) for storing data and/or instructions. In this regard, the memory may include one or more internally fixed storage units, removable storage units, and/or remotely accessible storage units, and the various storage units may include any combination of volatile memory and non-volatile memory. Logical instructions, commands, and/or code can be implemented in software, firmware, or both, and stored in memory. In this respect, the logic code may be implemented as one or more computer programs that can be executed by processing device 34.

**[0044]** In other embodiments, logical instructions, commands, and/or code can be implemented in hardware and incorporated in processing device 98 using discrete logic circuitry, an application specific integrated circuit (“ASIC”), a programmable gate array (“PGA”), a field programmable gate array (“FPGA”), etc., or any combination thereof. In yet other embodiments, logical instructions, commands, and/or code can be implemented in both hardware in processing device 98 and software/firmware stored in the memory.

**[0045]** Each output device represented by haptic actuator 100, visual display 102, and audio device 104 may include one or more of the respective output devices in any suitable form for providing haptic, visual, or audio outputs to the operator. Also, some output devices may be capable of providing multiple modes of communication in any combination. The output mechanisms may include any number of feedback mechanisms in any number of modes for providing any type of visual, audible, and/or tactile output to the operator. In the embodiments regarding surgical tools, the output mechanisms may be set up to provide feedback to the surgeon according to the surgeon’s preferences. With feedback tailored to the surgeon’s desires, the tool can provide feedback to supplement the operator experience for better operation and performance.

**[0046]** FIG. 8 is a flow diagram of an embodiment of a method of operation of a tool having multiple modes of feedback. As indicated in block 110, an operator is allowed to manipulate a tool according to a normal use of the tool. For example, the operator may manipulate a handle, buttons, or other feature on the tool to control a functional portion of the tool. The controlled portion may be a portion that is positioned on an opposite end of the tool from the handle. The controlled portion can be probed around to contact an object being tested or to be placed in proximity to the object being tested, depending on the particular type of parameter being measured.

**[0047]** As indicated in block 112, one or more properties of an object are sensed at a distal end of the tool. Particularly, the property or properties may be sensed by one or more sensing devices. The sensors may be positioned on or near the controlled portion of the tool. According to block 114, the sensed properties are processed to obtain output signals. Based on the properties sensed

and the types of output mechanisms incorporated in tool, output signals can be obtained for each particular output mechanism.

**[0048]** As indicated in block 116, operator selected settings are retrieved. In particular, the settings are selected to define how the output mechanisms are to be used in response to sensed signal. For example, the operator selected settings may include whether each respective output mechanism is enable or disabled, or turned on or off. Also, the settings may include level adjustment for factors associated with the different types of modes of communication, such as a haptic mode, visual mode, auditory mode, etc.

**[0049]** As indicated in block 118, the output signals are provided to the one or more output mechanisms. Thus, the sensed signals are communicated to the operator in one or more different output modes, depending on the modes selected by the operator. The outputs may be haptic outputs, vibrotactile effect outputs, visual outputs, auditory outputs, or any combination of these or other outputs.

**[0050]** It should be understood that the routines, steps, processes, or operations described herein may represent any module or code sequence that can be implemented in software or firmware. In this regard, these modules and code sequences can include commands or instructions for executing the specific logical routines, steps, processes, or operations within physical components. It should further be understood that two or more of the routines, steps, processes, and/or operations described herein may be executed substantially simultaneously or in a different order than explicitly described, as would be understood by one of ordinary skill in the art.

**[0051]** The embodiments described herein represent a number of possible implementations and examples and are not intended necessarily to limit the present disclosure to any specific embodiments. Instead, various modifications can be made to these embodiments as would be understood by one of ordinary skill in the art. Any such modifications are intended to be included within the spirit and scope of the present disclosure and protected by the following claims.

## CLAIMS

We claim:

1. A tool comprising:  
a handle portion and a distal portion;  
a sensor mounted on the distal portion, the sensor configured to generate sensor signals representing one or more characteristics of an object;  
a processing device configured to process the sensor signals to generate one or more output signals; and  
an output system mounted on the handle portion, the output system including one or more output mechanisms selected from the group consisting of a haptic device, a visual device, and an audio device;  
wherein the processing device is further configured to apply the one or more output signals to the one or more output mechanisms.
2. The tool of claim 1, further comprising a shaft connecting the handle portion with the distal portion.
3. The tool of claim 2, further comprising a rotary device mounted on the handle portion, the rotary device configured to rotate the sensor about an axis formed by the shaft.
4. The tool of claim 1, further comprising a set of switches.
5. The tool of claim 4, wherein one or more of the switches is configured to enable an operator to select which ones of the output mechanisms are enabled.
6. The tool of claim 5, wherein one or more of the switches is configured to enable the operator to adjust output parameters of the enabled output mechanisms.

7. The tool of claim 6, further comprising a level meter mounted on the handle portion, the level meter being configured to indicate how the parameters of the enabled output mechanisms are adjusted.

8. The tool of claim 1, wherein one of the output mechanisms is a visual device, the visual device comprising a liquid crystal display (LCD) screen.

9. The tool of claim 1, wherein one of the output mechanisms includes a device configured to provide both visual and haptic outputs.

10. The tool of claim 1, wherein the tool is a surgical tool and the object is a patient.

11. The tool of claim 10, wherein the surgical tool is a laparoscopic tool.

12. A method comprising:  
allowing an operator to manipulate a tool having a plurality of output mechanisms mounted thereon;  
sensing a property of an object located near or adjacent to a distal portion of the tool;  
processing the sensed property to obtain one or more output signals; and  
applying the one or more output signals to one or more of the output mechanisms.

13. The method of claim 12, wherein the method further comprises allowing the operator to enable or disable each of the one or more output mechanisms.



14. The method of claim 12, wherein the method further comprises allowing the operator to adjust parameters associated with the operation of the output mechanisms.

15. The method of claim 12, wherein applying the one or more output signals further comprises applying at least one visual signal to a video display device, applying at least one audio signal to an audio device, and applying at least one haptic signal to a haptic actuator.

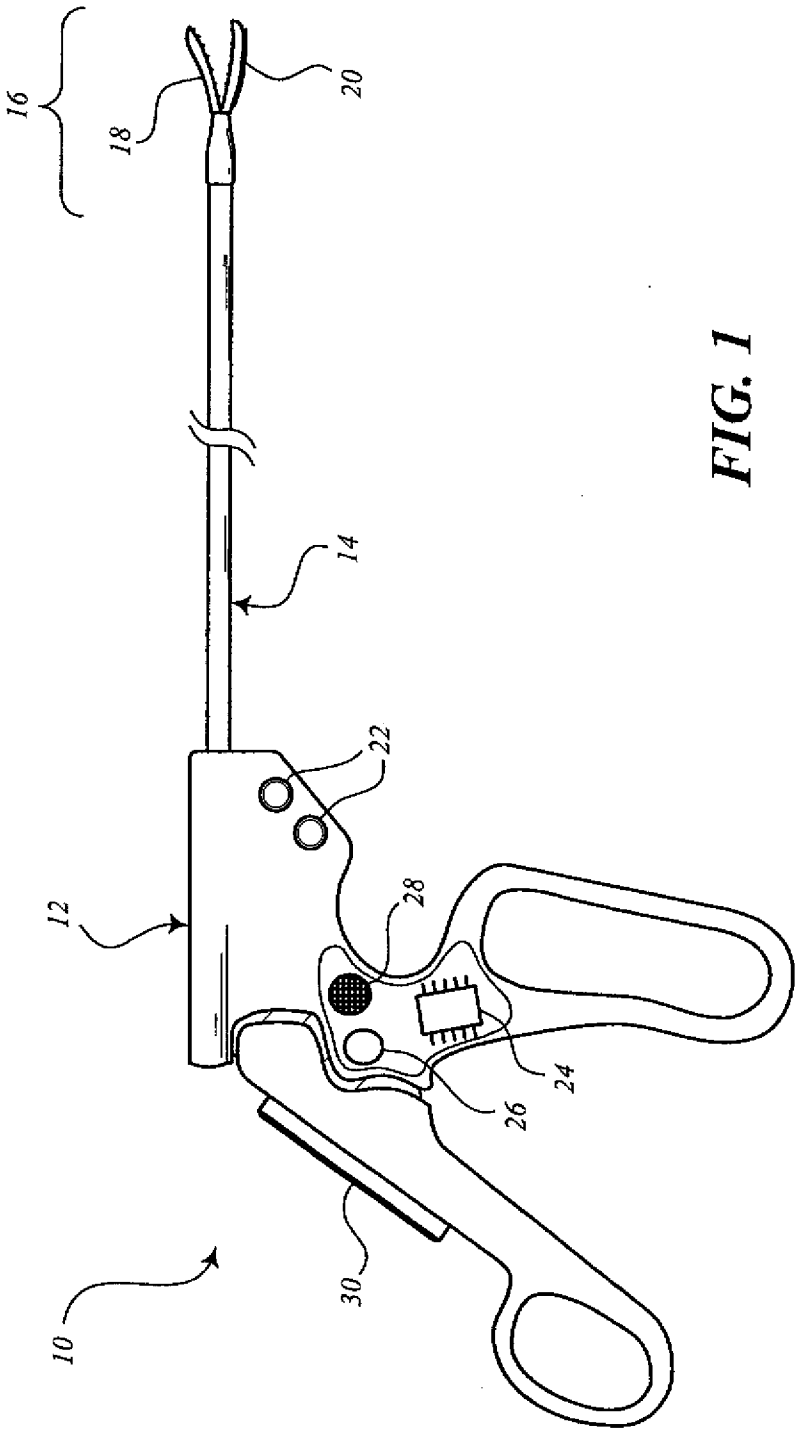
16. The method of claim 12, wherein applying the one or more output signals further comprises applying output signals related to both visual and haptic parameters to a single output mechanism configured to provide both visual and haptic outputs.

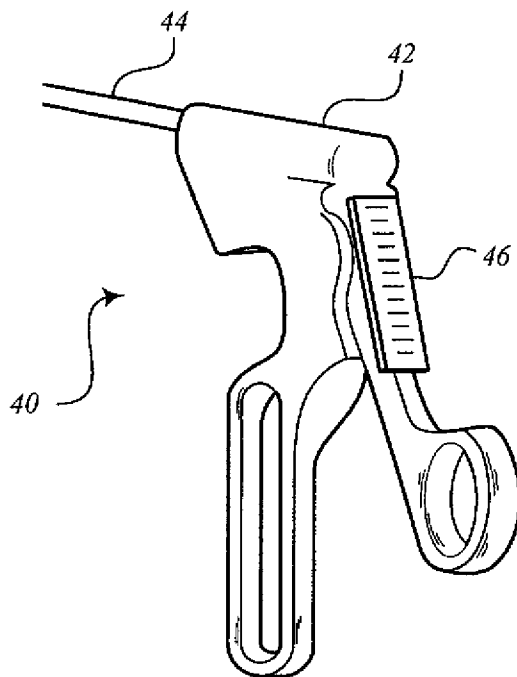
17. A surgical tool comprising:  
means for obtaining a sensory signal indicative of a characteristic of a patient under observation, the obtaining means configured to obtain the sensory signal at a distal end of the surgical tool;  
means for processing the characteristic to generate one or more output signals; and  
means for providing the one or more output signals to one or more output devices configured to provide feedback information in multiple modes, wherein the multiple modes include at least a visual mode and a haptic mode.

18. The surgical tool of claim 17, wherein the means for obtaining the sensory signal is further configured to obtain multiple sensory signals, a first set of sensory signals comprising visual sensory signals and a second set of sensory signal comprising haptic sensory signals.

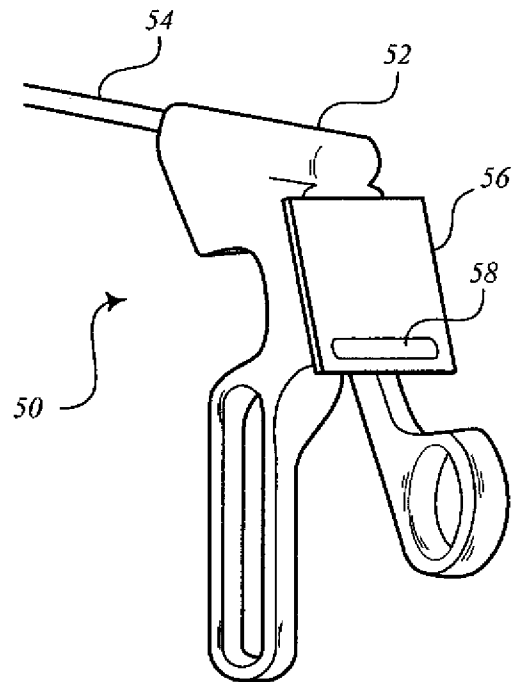
19. The surgical tool of claim 17, wherein the means for providing is further configured to provide the output signals in at least a visual mode, a haptic mode, and an auditory mode.

20. The surgical tool of claim 19, wherein the one or more output devices include at least one visual display device, at least one haptic actuator, and at least one audio device.

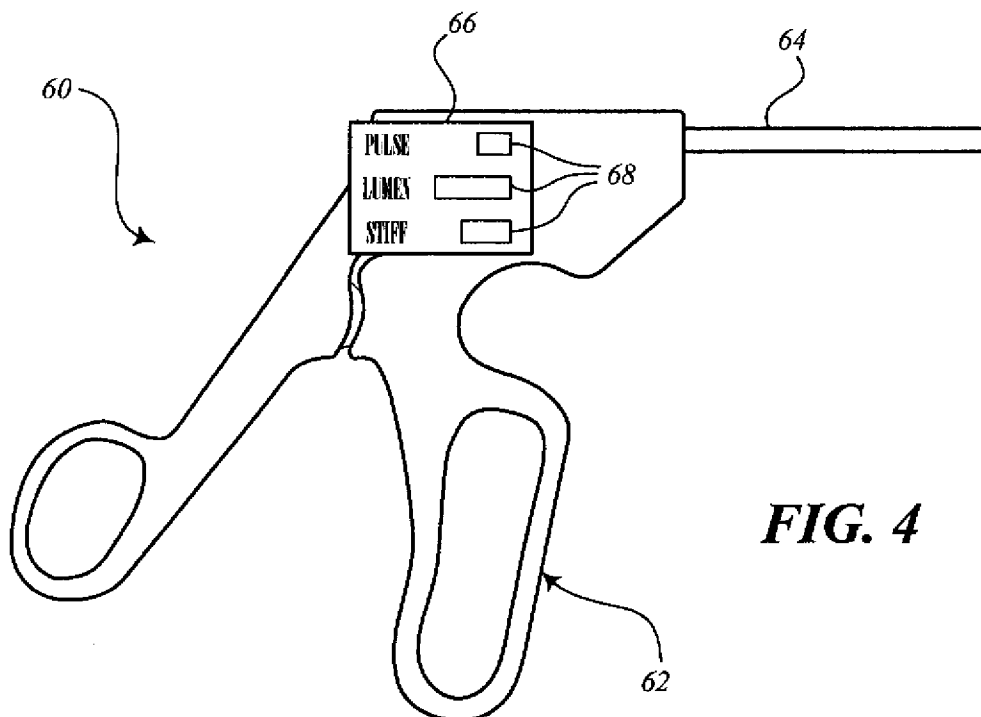




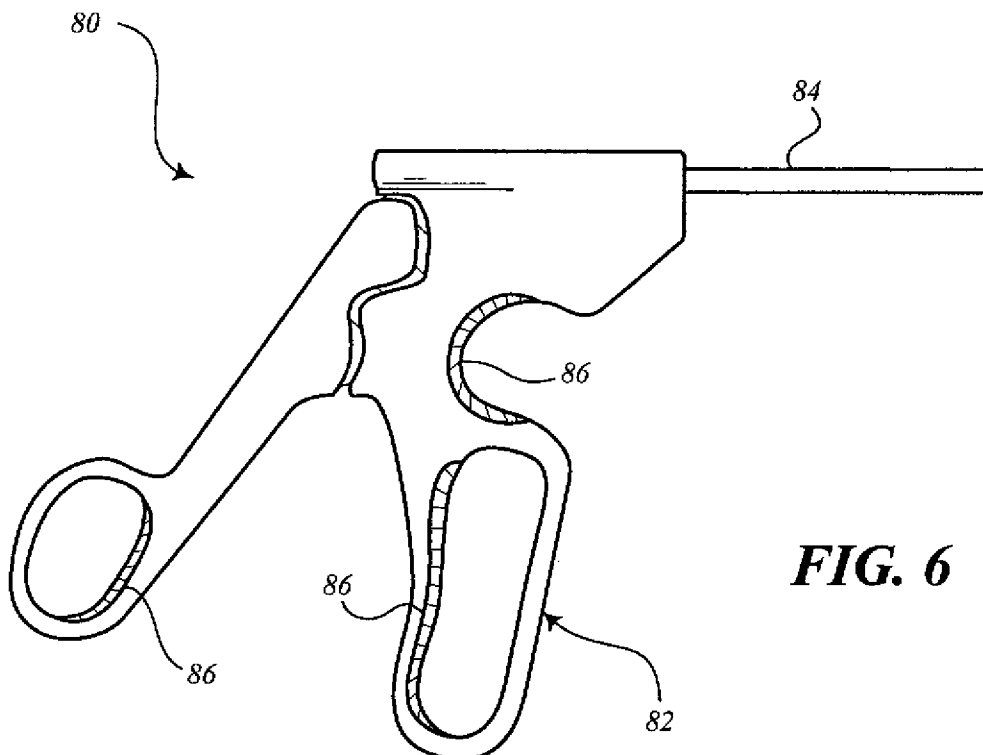
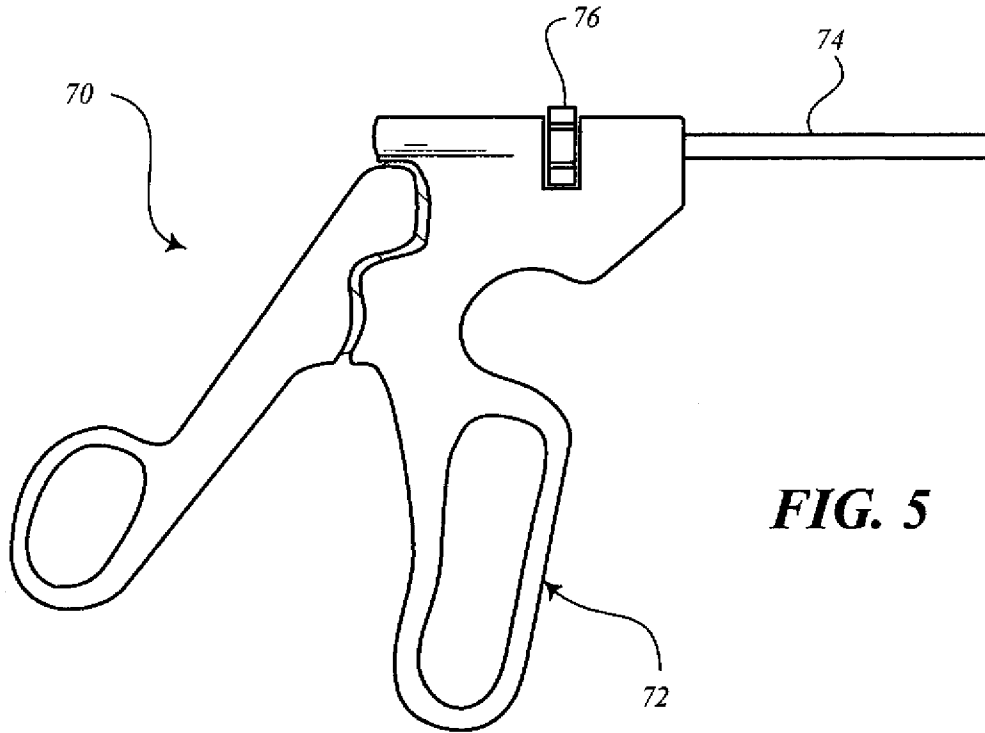
**FIG. 2**

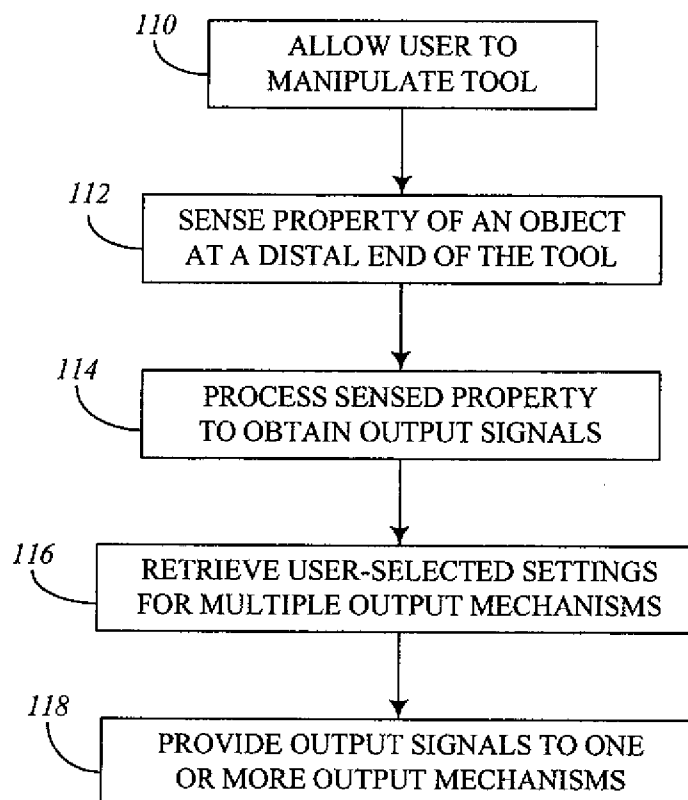
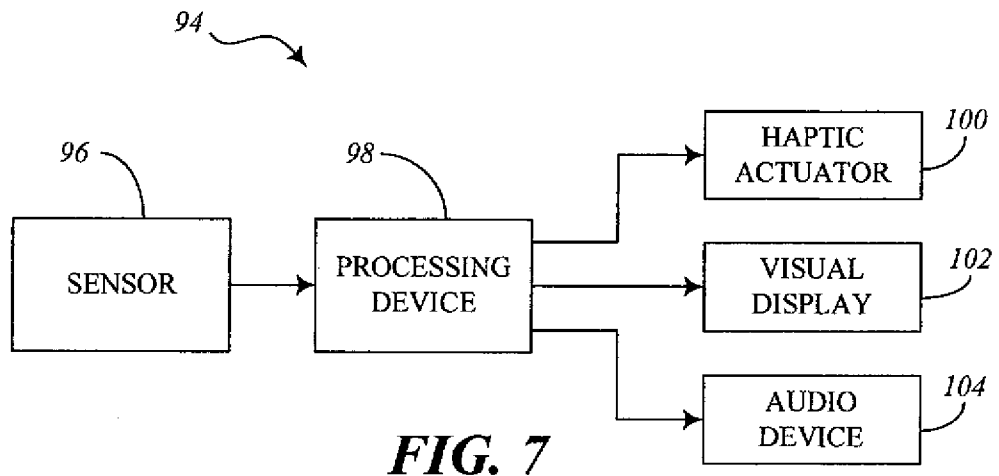


**FIG. 3**



**FIG. 4**



**FIG. 8**

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2009/065034

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> INV. A61B17/00 A61B17/28		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) A61B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2 520 942 A1 (UNIV KINGSTON [CA]; UNIV MCGILL [CA]) 23 March 2007 (2007-03-23)	1-2, 9-10, 17-20
Y	page 11 - page 13; figure 1 -----	3-6
X	WO 03/020139 A2 (VLEUGELS MICHEL PETRONELLA HUB [NL]; LAZEROMS MARKUS CORNELIS JACOB [B]) 13 March 2003 (2003-03-13) page 4; figure 1 -----	1-2, 10-11
X	US 2002/120188 A1 (BROCK DAVID L [US] ET AL) 29 August 2002 (2002-08-29) paragraph [0077] - paragraph [0084]; figure 3 ----- -/--	17, 19-20
<div style="display: flex; justify-content: space-between;"> <span><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.</span> <span><input checked="" type="checkbox"/> See patent family annex.</span> </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>*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</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>*&amp;* document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search  <div style="text-align: center; font-weight: bold;">28 January 2010</div>		Date of mailing of the international search report  <div style="text-align: center; font-weight: bold;">04/02/2010</div>
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer  <div style="text-align: center; font-weight: bold;">Chopinaud, Marjorie</div>

# INTERNATIONAL SEARCH REPORT

International application No

PCT/US2009/065034

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/49227 A1 (UNIV JOHNS HOPKINS [US]; JUAN EUGENE JR DE [US]; JENSEN PATRICK S [US]) 12 July 2001 (2001-07-12) the whole document -----	1,10
Y	EP 1 769 756 A1 (ETHICON ENDO SURGERY INC [US]) 4 April 2007 (2007-04-04) the whole document -----	3-6
A		7-20



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2009/065034

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

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

1. ☒ Claims Nos.: 12-16  
because they relate to subject matter not required to be searched by this Authority, namely:  
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

#### Remark on Protest

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

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2009/065034

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
CA 2520942	A1	23-03-2007	US 2007135735 A1	14-06-2007
WO 03020139	A2	13-03-2003	EP 1423056 A2	02-06-2004
			NL 1018874 C2	05-03-2003
			US 2005021078 A1	27-01-2005
US 2002120188	A1	29-08-2002	NONE	
WO 0149227	A1	12-07-2001	AU 2624701 A	16-07-2001
			AU 2626401 A	16-07-2001
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EP 1769756	A1	04-04-2007	AT 454094 T	15-01-2010
			AU 2006222763 A1	19-04-2007
			CA 2561241 A1	30-03-2007
			CN 1939230 A	04-04-2007
			JP 2007098130 A	19-04-2007

专利名称(译)	具有多个反馈设备的工具		
公开(公告)号	<a href="#">EP2296555A1</a>	公开(公告)日	2011-03-23
申请号	EP2009756387	申请日	2009-11-19
[标]申请(专利权)人(译)	伊梅森公司		
申请(专利权)人(译)	Immersion公司		
当前申请(专利权)人(译)	Immersion公司		
[标]发明人	RAMSTEIN CHRISTOPHE ULLRICH CHRISTOPHER J GRANT DANNY A		
发明人	RAMSTEIN, CHRISTOPHE ULLRICH, CHRISTOPHER, J. GRANT, DANNY, A.		
IPC分类号	A61B17/00 A61B17/28		
CPC分类号	A61B17/00234 A61B17/29 A61B34/76 A61B2017/00022 A61B2017/00115 A61B2017/00199 A61B2090/065 A61B2090/0811 A61B2090/372		
优先权	12/327104 2008-12-03 US		
其他公开文献	EP2296555B1		
外部链接	<a href="#">Espacenet</a>		

#### 摘要(译)

本文公开了用于管理如何将工具上感测的信号呈现给工具的操作者的系统和方法。根据用于管理信号的方法的一个示例，该方法包括允许操作者操纵其上安装有多输出机构的工具。该方法还包括感测位于工具的远端部分附近或附近的物体的特性，并处理感测的特性以获得一个或多个输出信号。此外，该方法包括将一个或多个输出信号应用于一个或多个输出机制。