US 20190051409A1

(19) United States
(12) Patent Application Publication
Petrossian et al.
(10) Pub. No.: US 2019/0051409 A1
(43) Pub. Date: Feb. 14, 2019

(54) MULTI-DEVICE SYSTEM

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(21) Appl. No.: **16/101,332**

(22) Filed: **Aug. 10, 2018**

Related U.S. Application Data

(60) Provisional application No. 62/544,362, filed on Aug. 11, 2017.

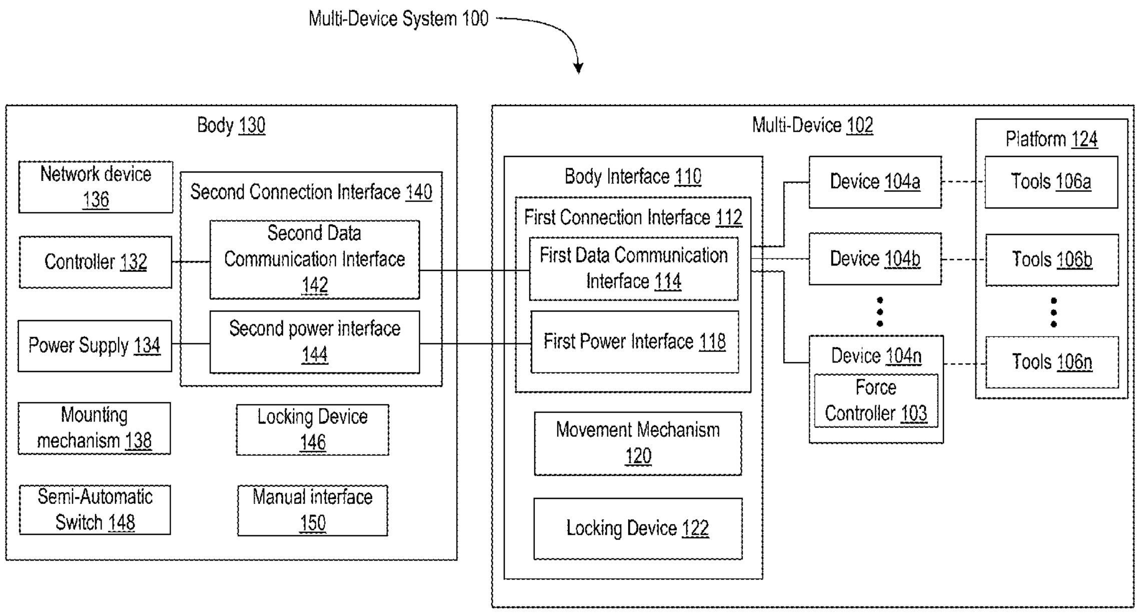
Publication Classification

(51) **Int. Cl.**
G16H 40/60 (2006.01)
A61B 5/00 (2006.01)
G06F 3/01 (2006.01)

(52) **U.S. Cl.**
CPC ***G16H 40/60*** (2018.01); ***A61B 5/0024*** (2013.01); ***A61B 5/0036*** (2018.08); ***A61B 5/0035*** (2013.01); ***G06F 3/011*** (2013.01)

(57) **ABSTRACT**

Arrangements described herein relate to a multi-device system configured to provide healthcare to a subject. The multi-device system includes a multi-device having a body interface, a plurality of devices fixed to the body interface, each of the plurality of devices configured to collect data of the subject, and a body operatively coupled to the multi-device at the body interface. The body is configured to position the multi-device with respect to the subject. The body interface is configured to move relative to the body to selectively activate at least one of the plurality of devices.



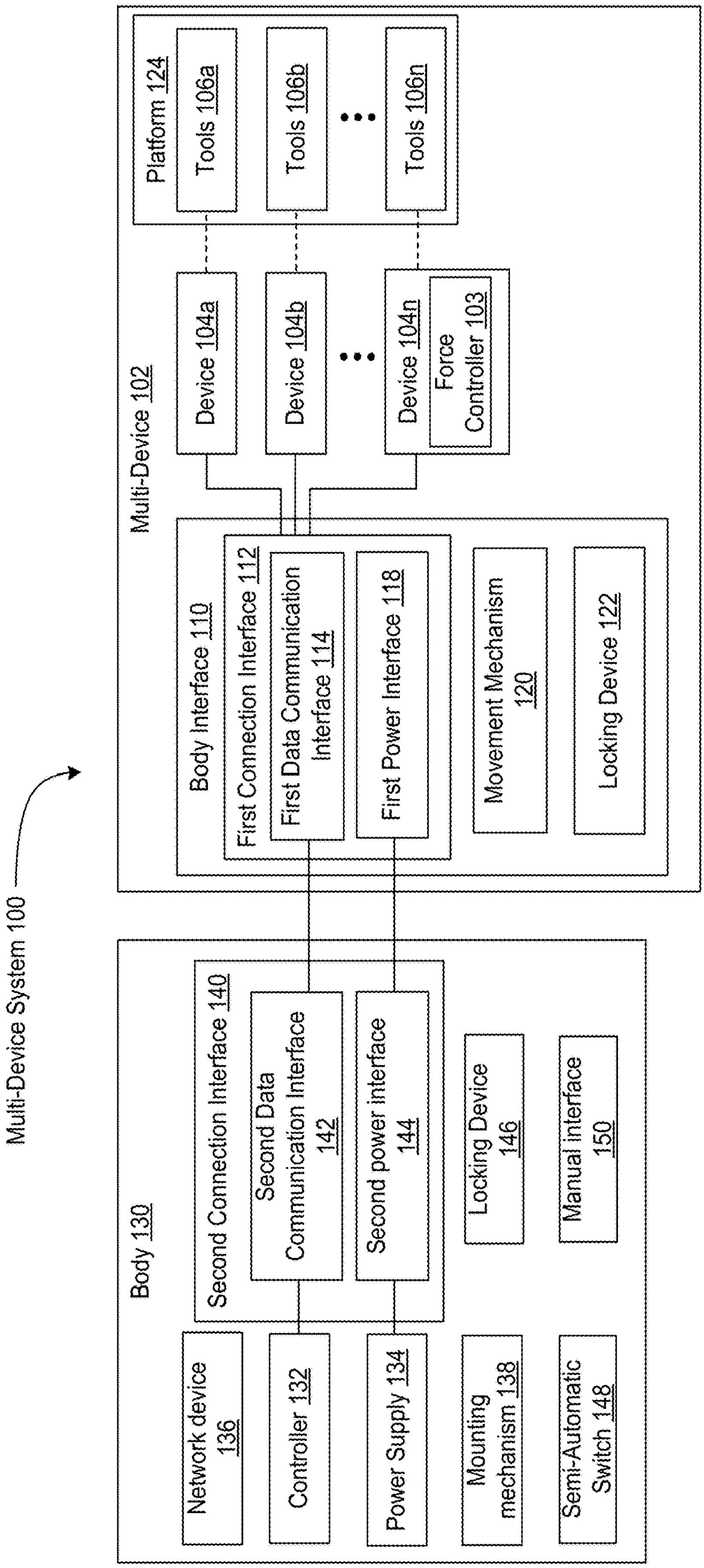

Multi-Device System 100
Multi-Device 102
Platform 124
Tools 106a
Tools 106b
Tools 106n
Device 104a
Device 104b
Device 104n
Force Controller 103
Body Interface 110
First Connection Interface 112
First Data Communication Interface 114
First Power Interface 118
Movement Mechanism 120
Locking Device 122
Body 130
Second Connection Interface 140
Second Data Communication Interface 142
Second power interface 144
Locking Device 146
Manual interface 150
Network device 136
Controller 132
Power Supply 134
Mounting mechanism 138
Semi-Automatic Switch 148

FIG. 1

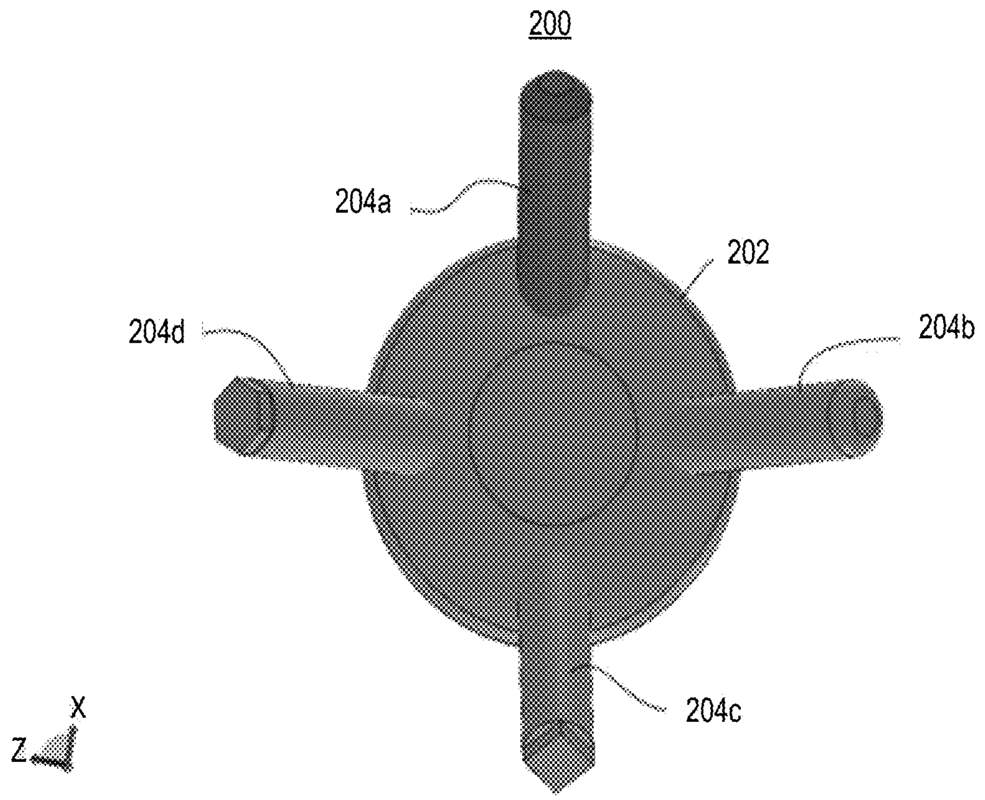


FIG. 2A

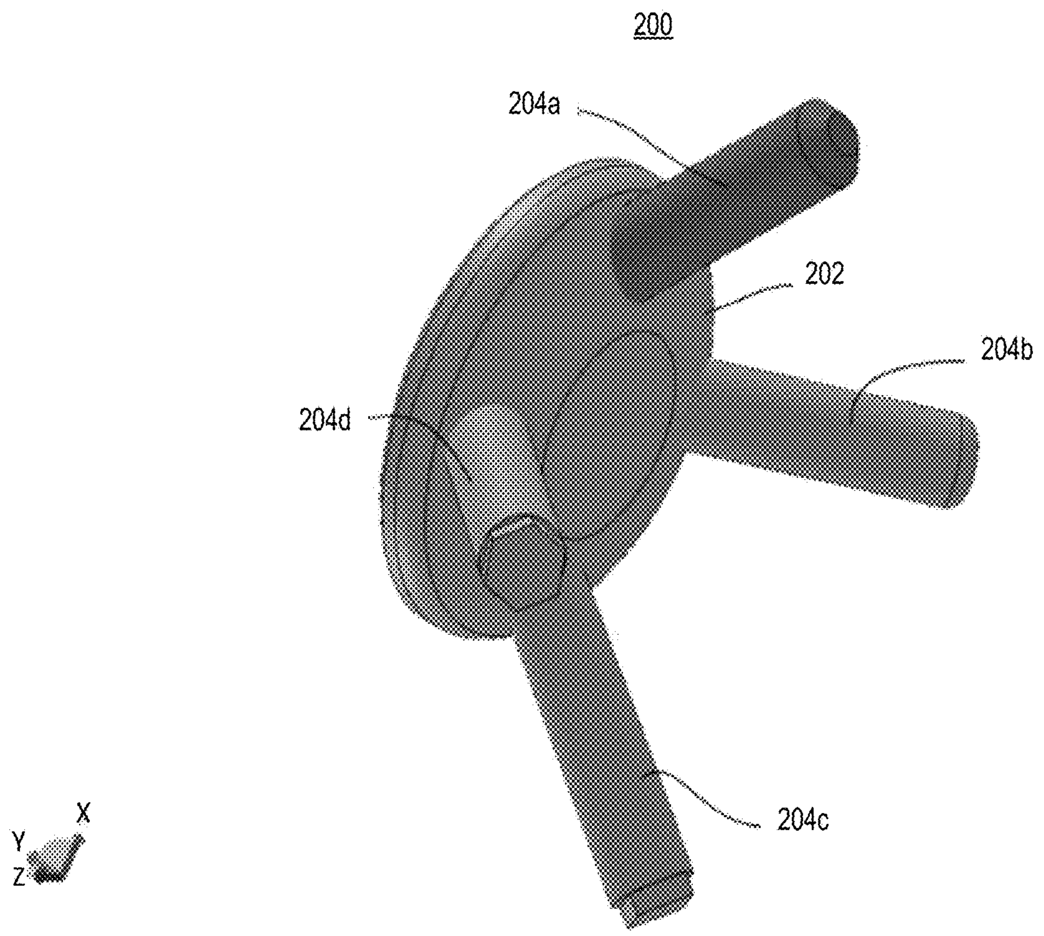


FIG. 2B

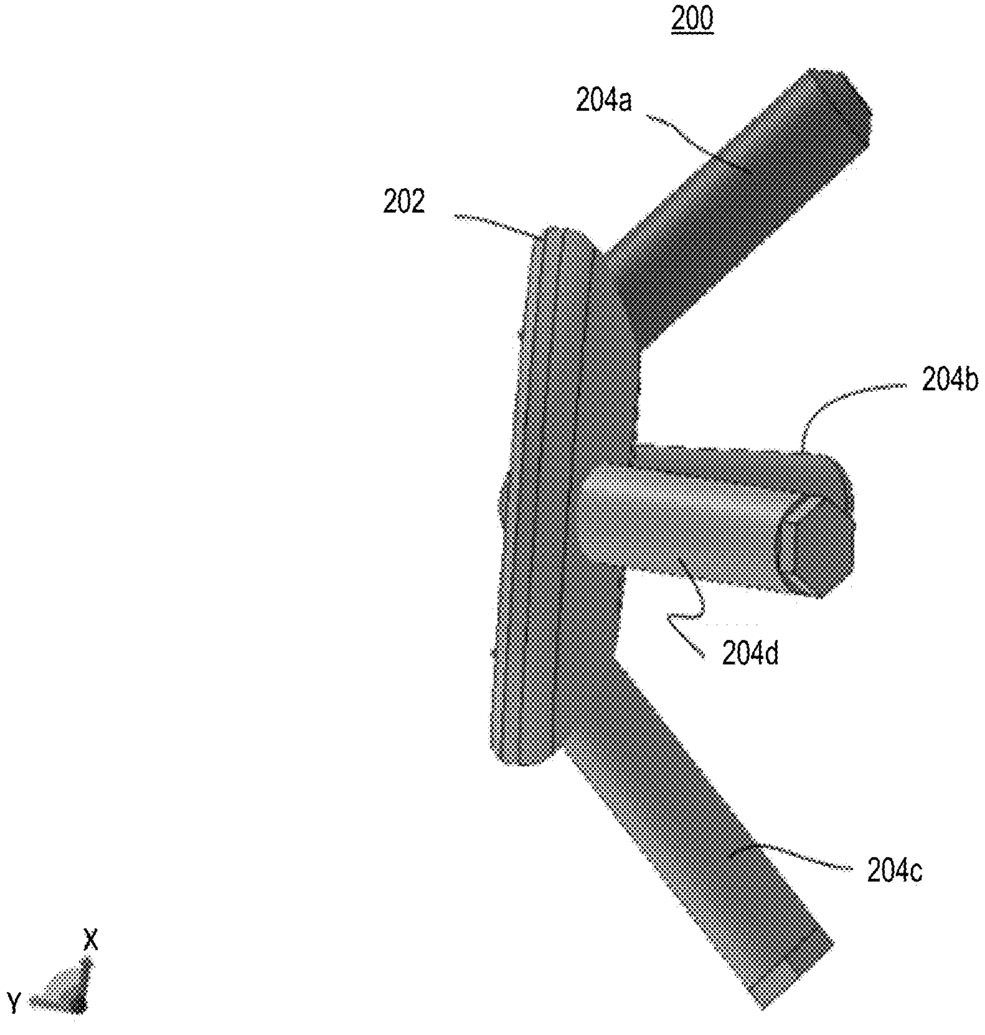


FIG. 2C

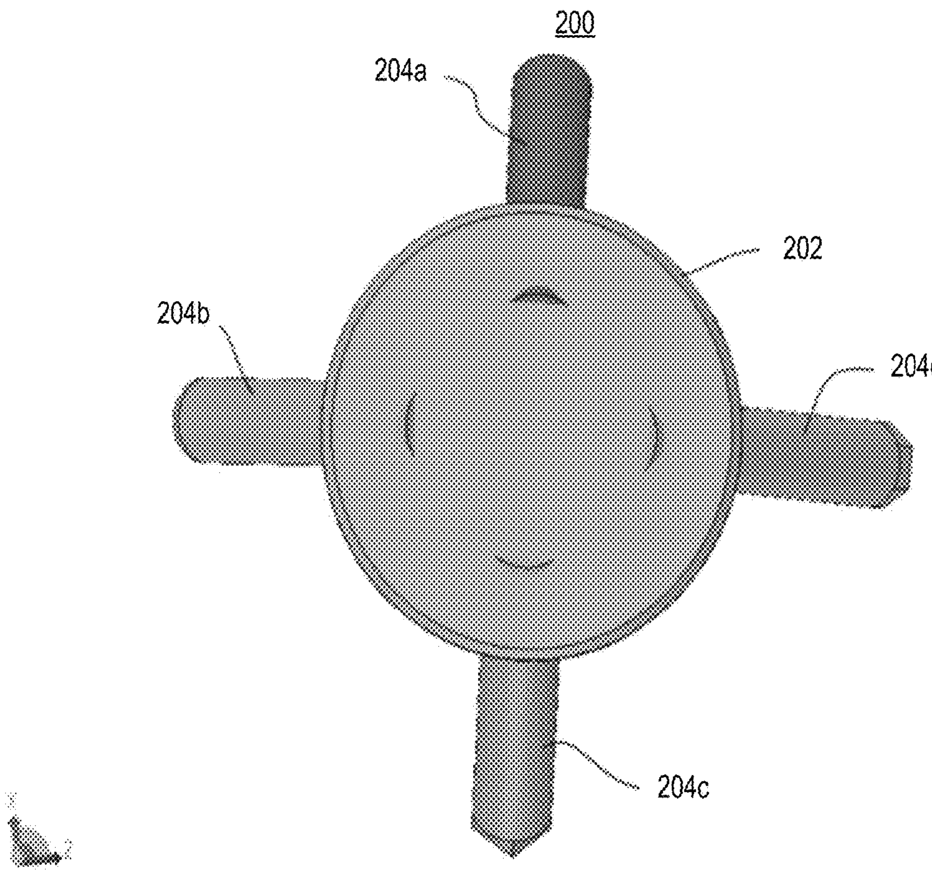


FIG. 2D

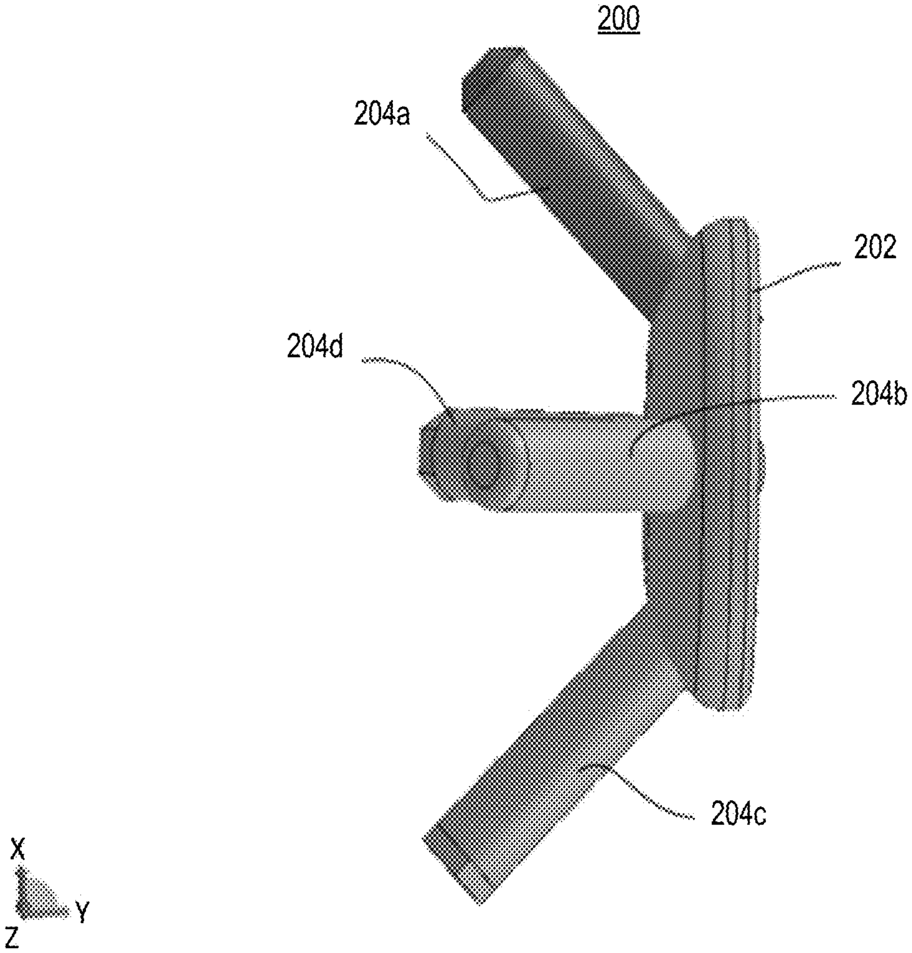


FIG. 2E

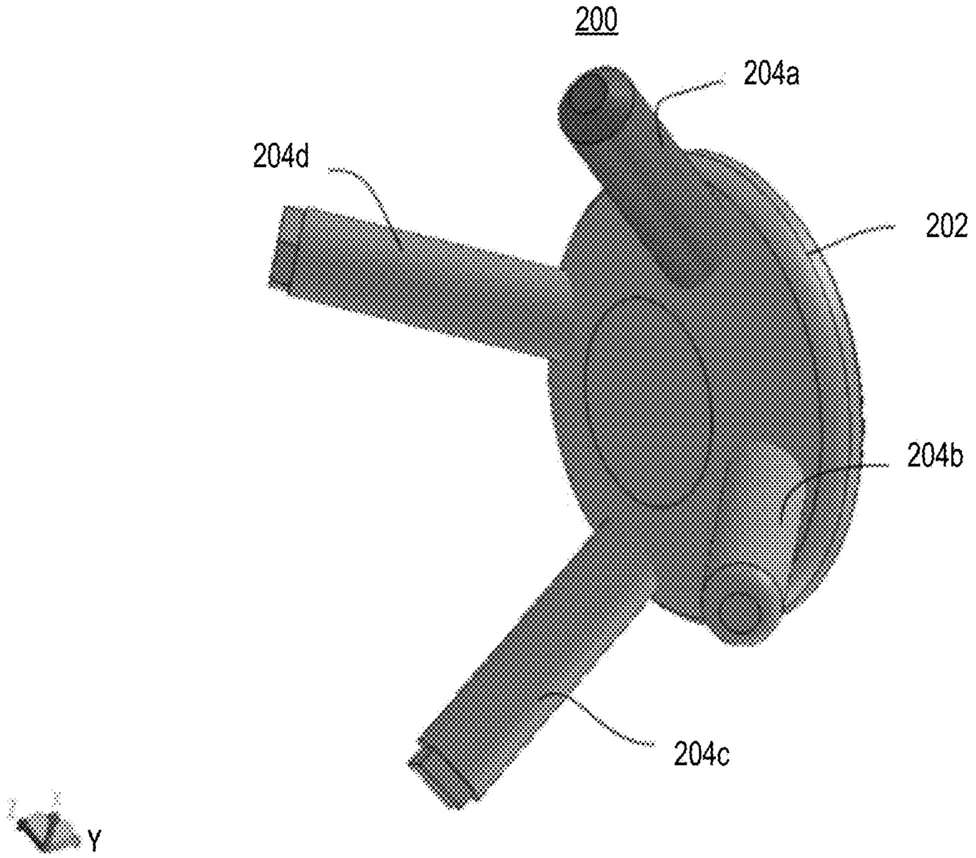


FIG. 2F

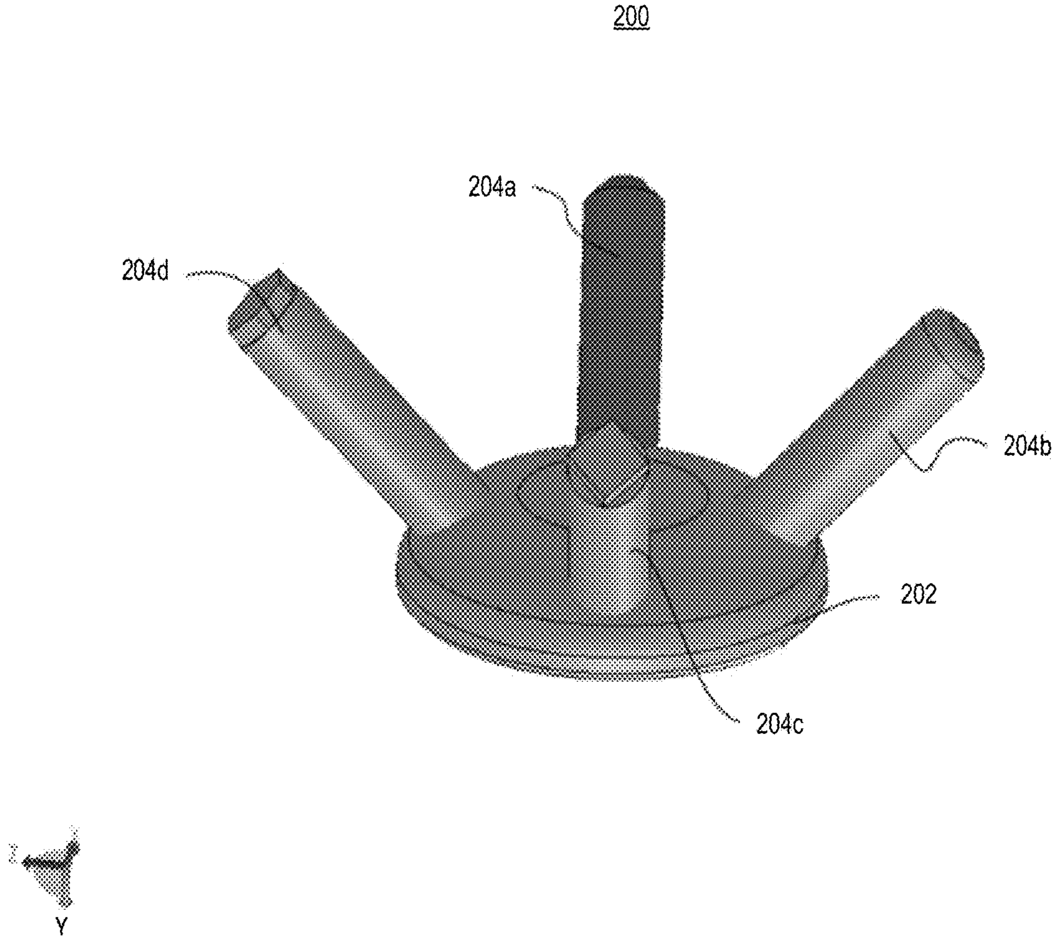


FIG. 2G

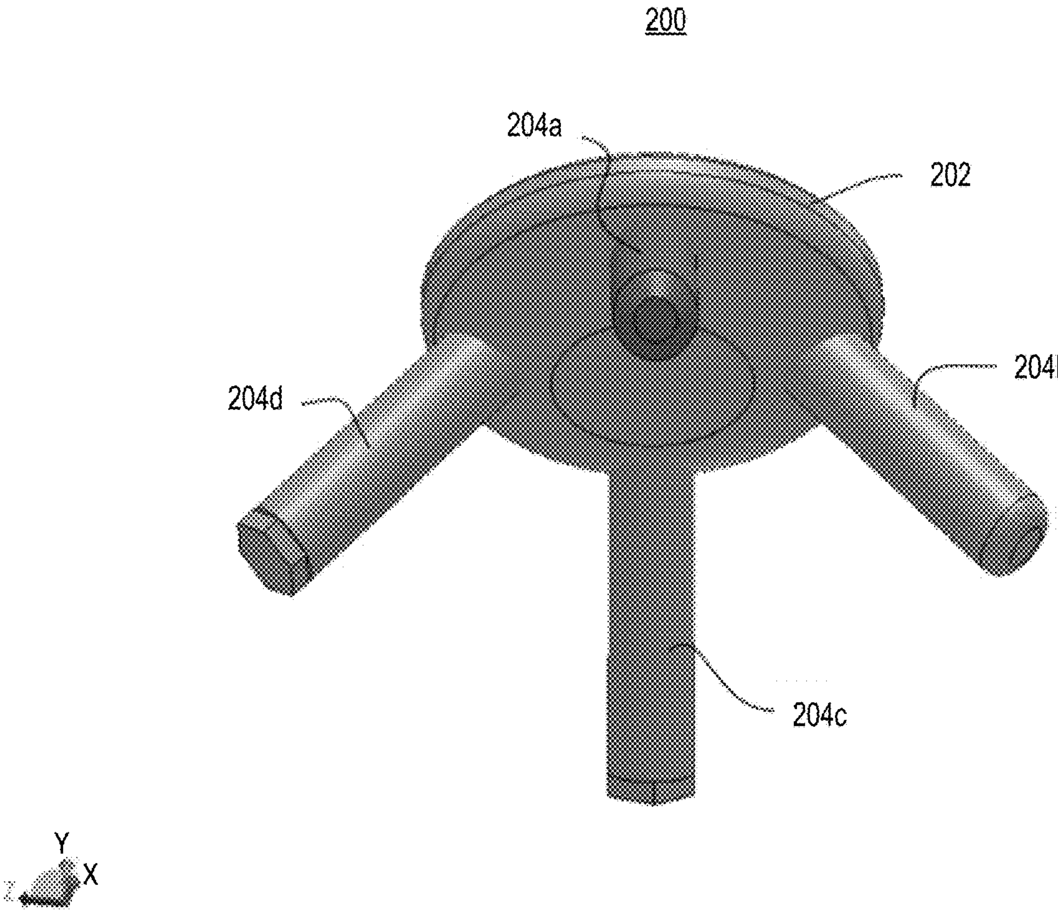


FIG. 2H

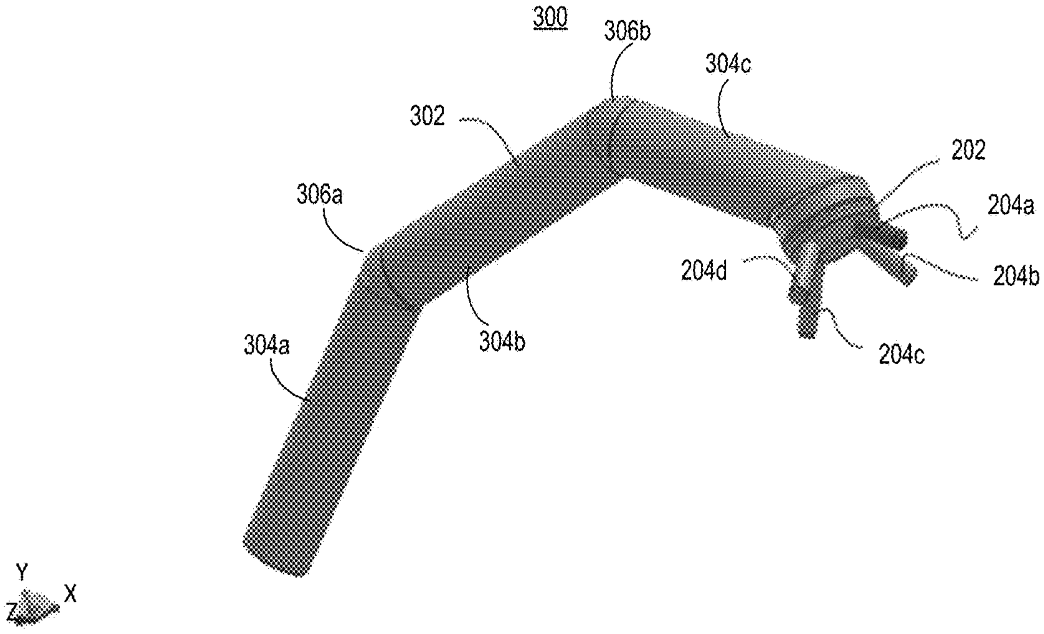


FIG. 3A

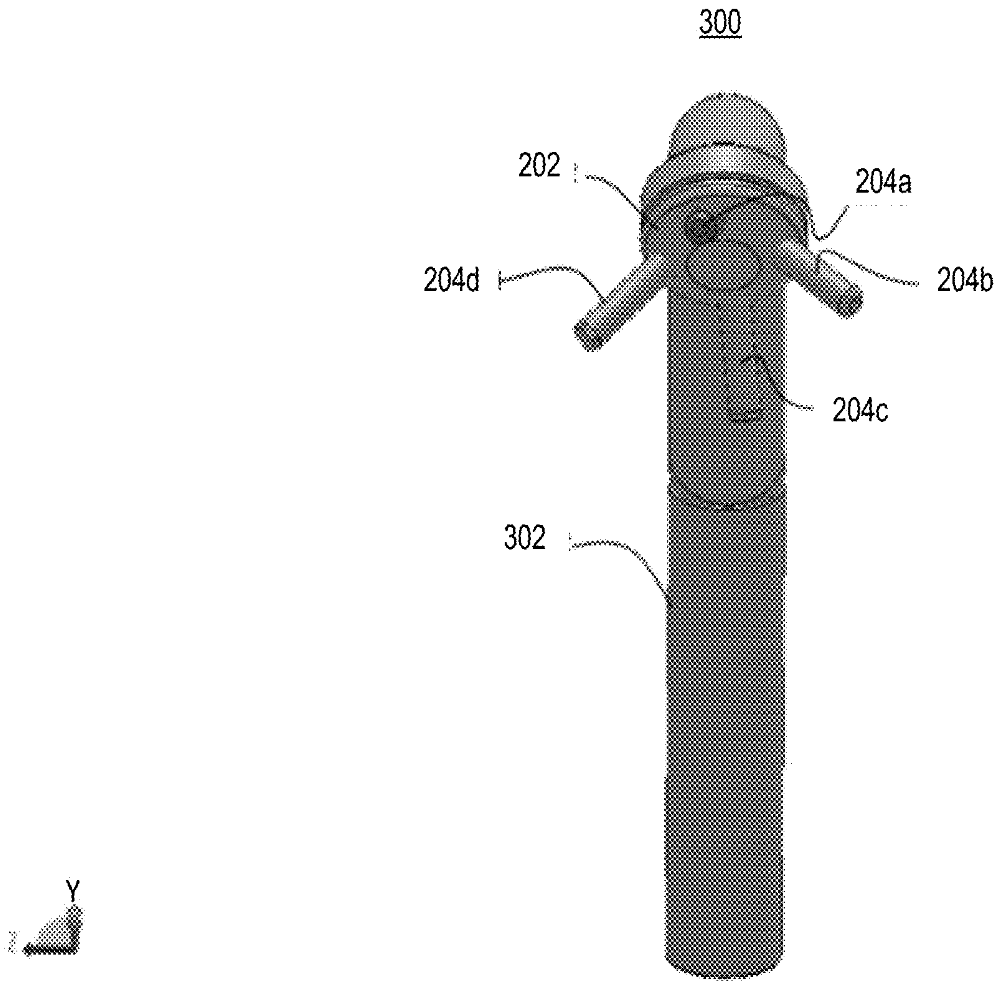


FIG. 3B

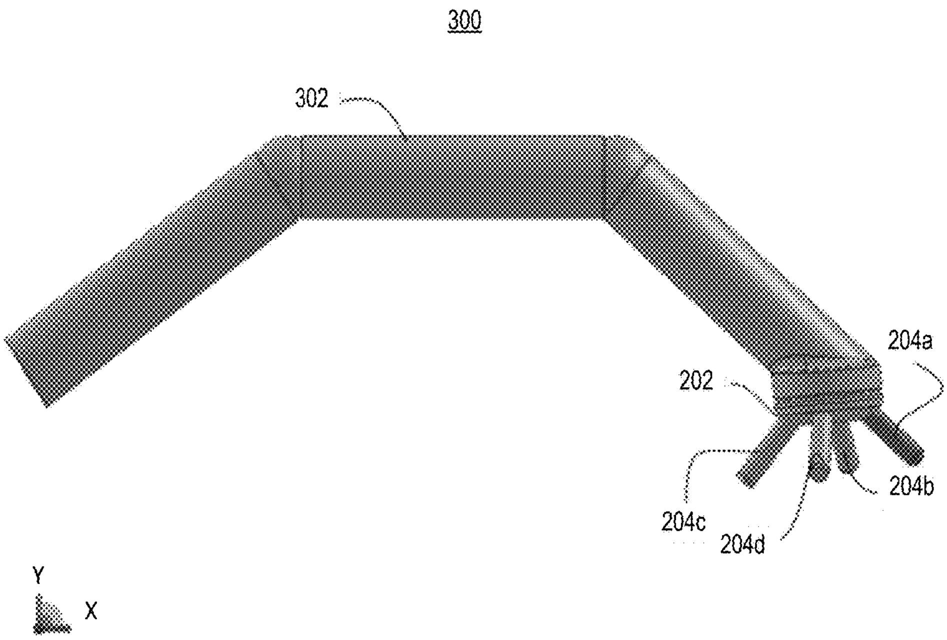


FIG. 3C

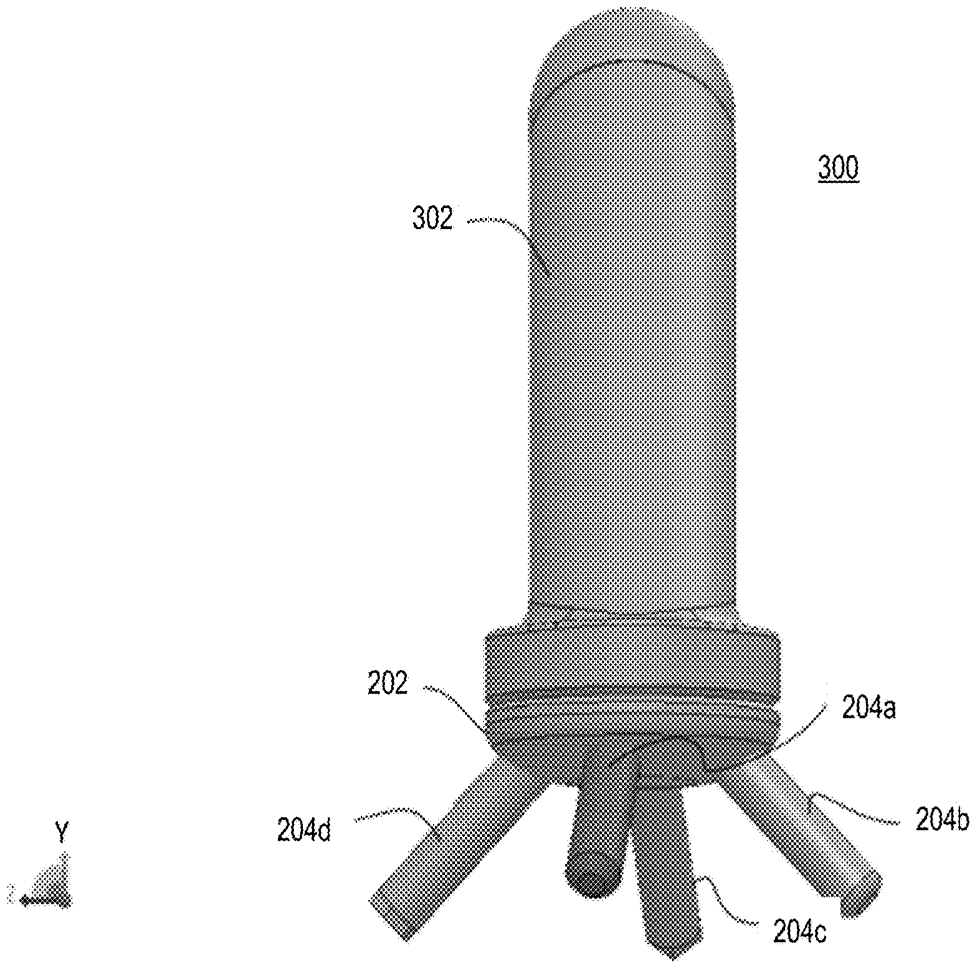


FIG. 3D

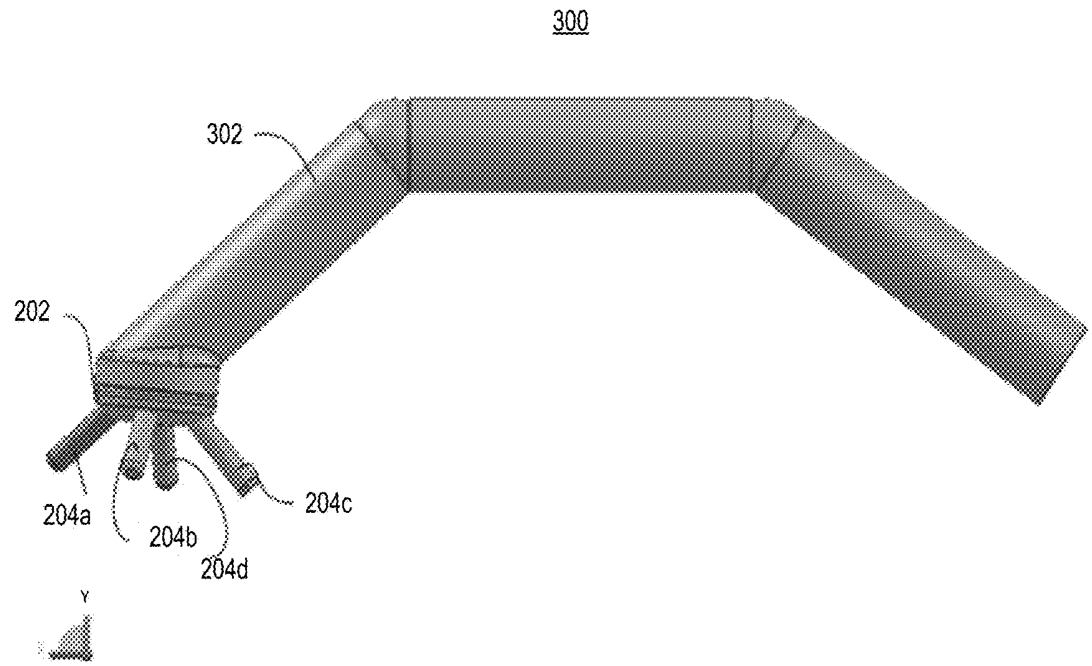


FIG. 3E

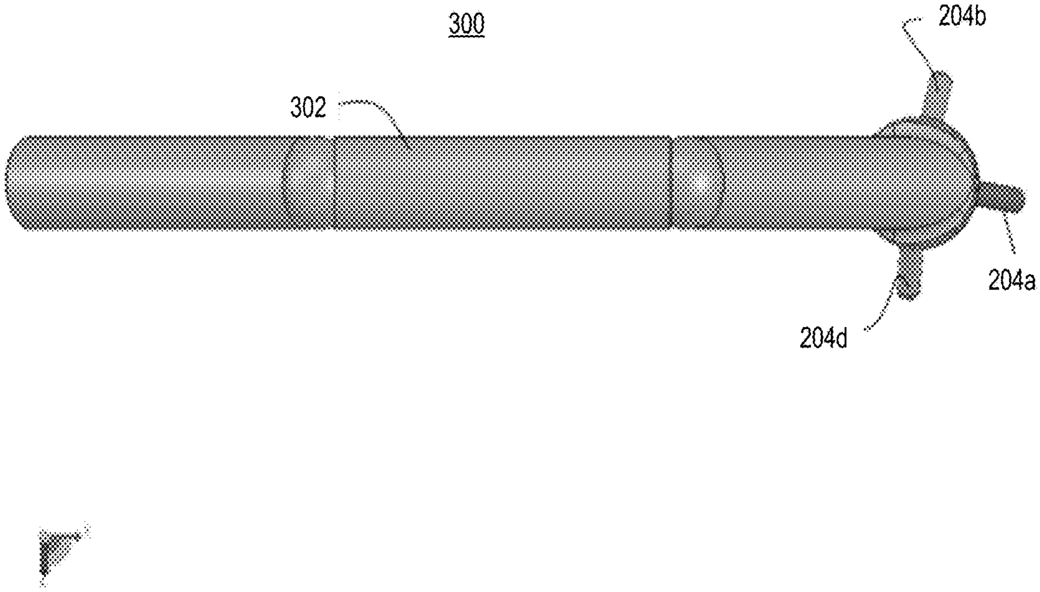


FIG. 3F

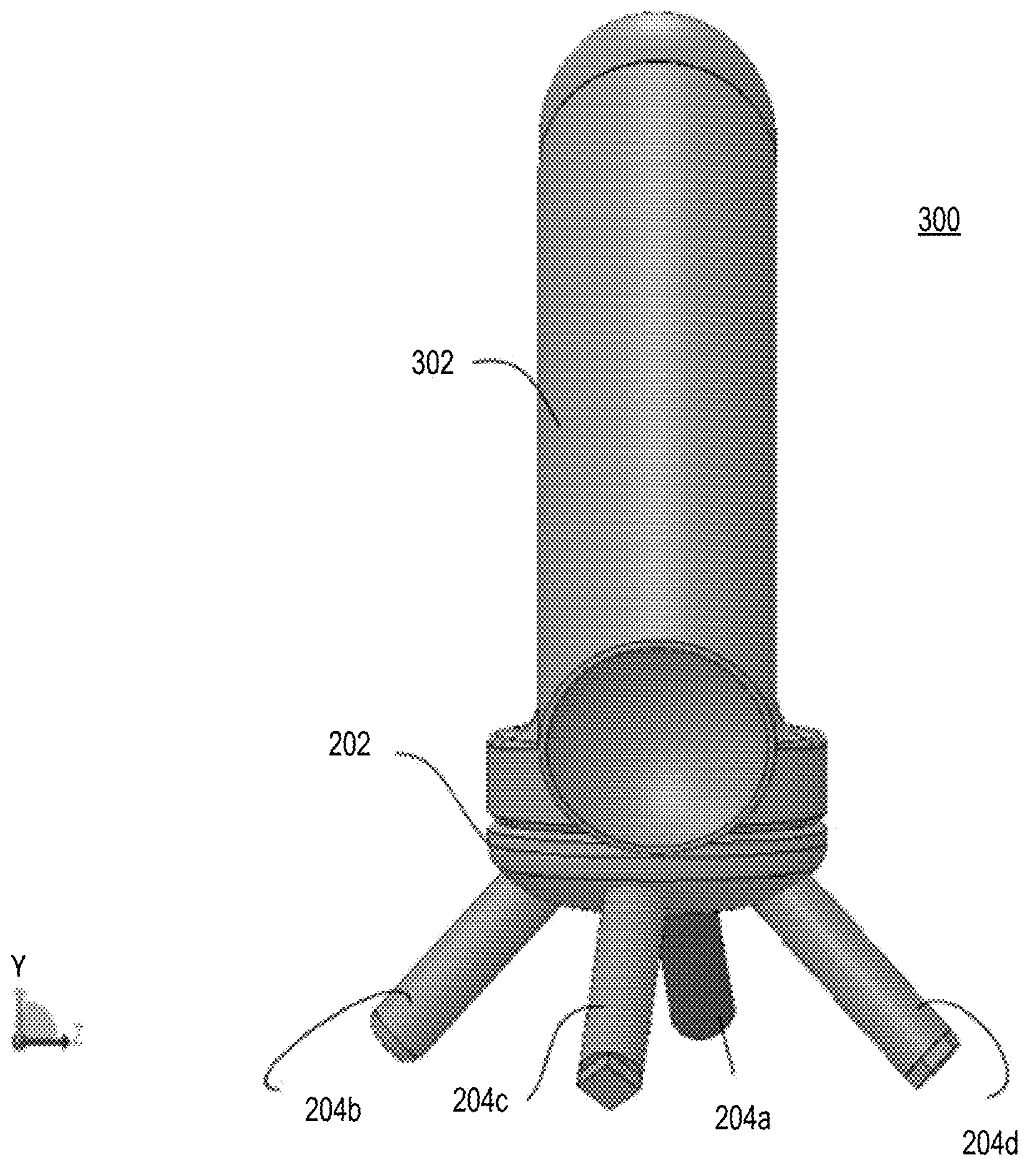


FIG. 3G

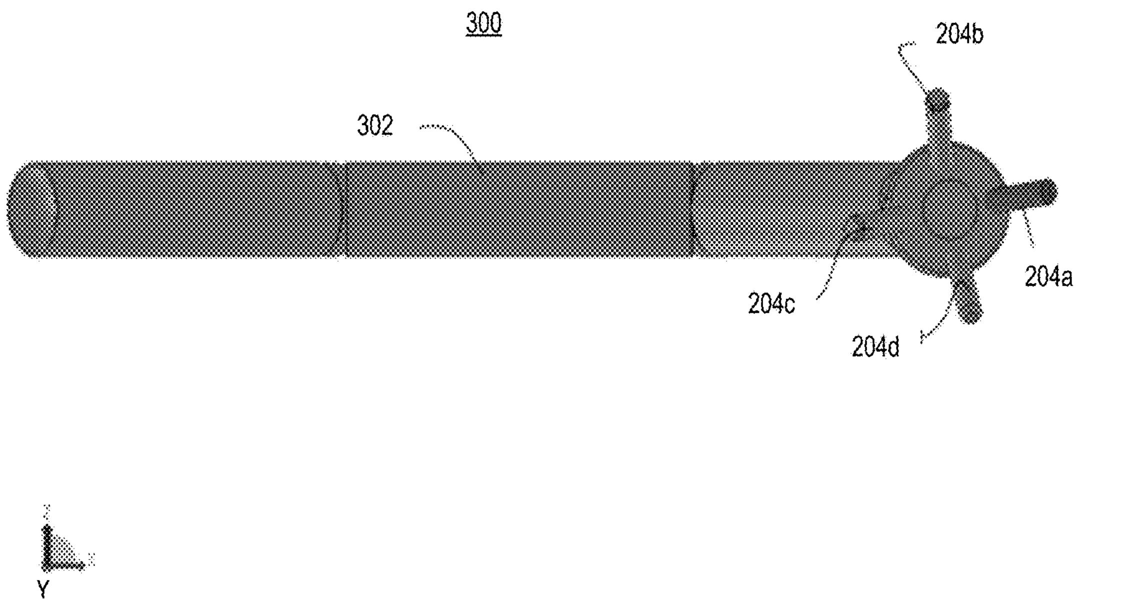


FIG. 3H

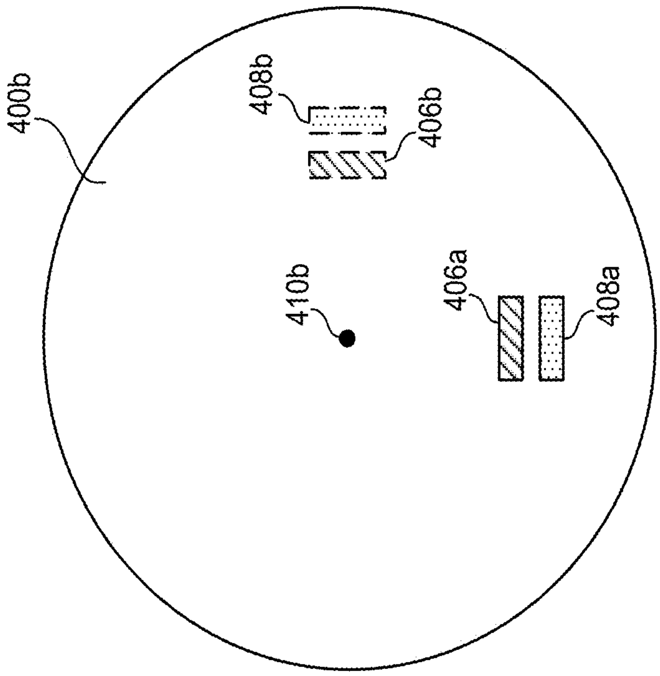

400b
408b
406b
410b
406a
408a

FIG. 4B

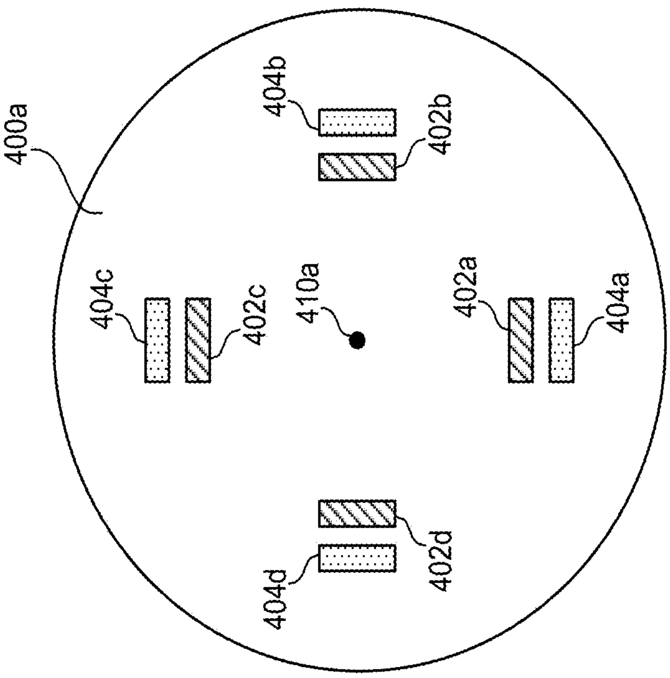

400a
404b
402b
404c
402c
410a
402a
404a
402d
404d

FIG. 4A

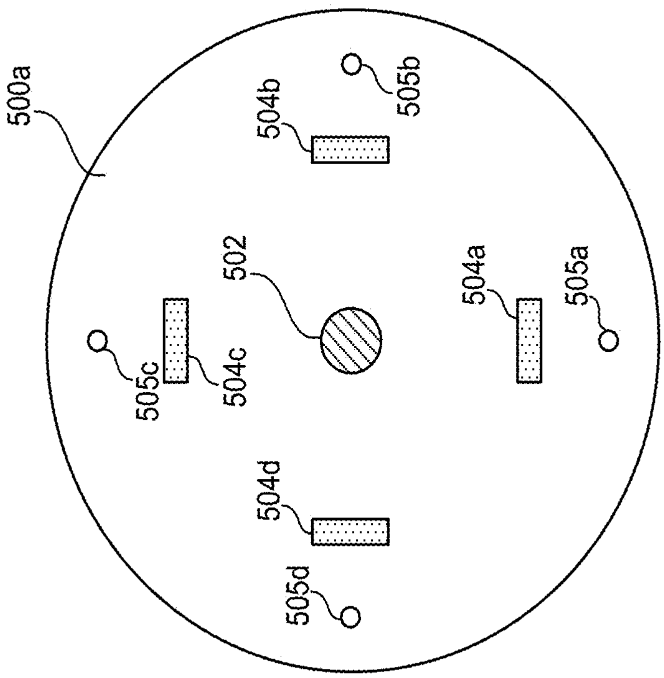

500a
502
504a
504b
504c
504d
505a
505b
505c
505d

FIG. 5A

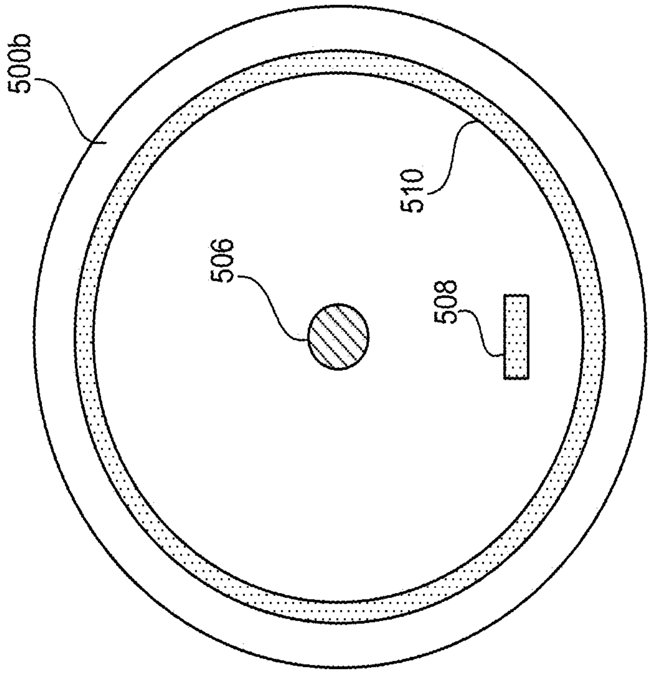

500b
506
508
510

FIG. 5B

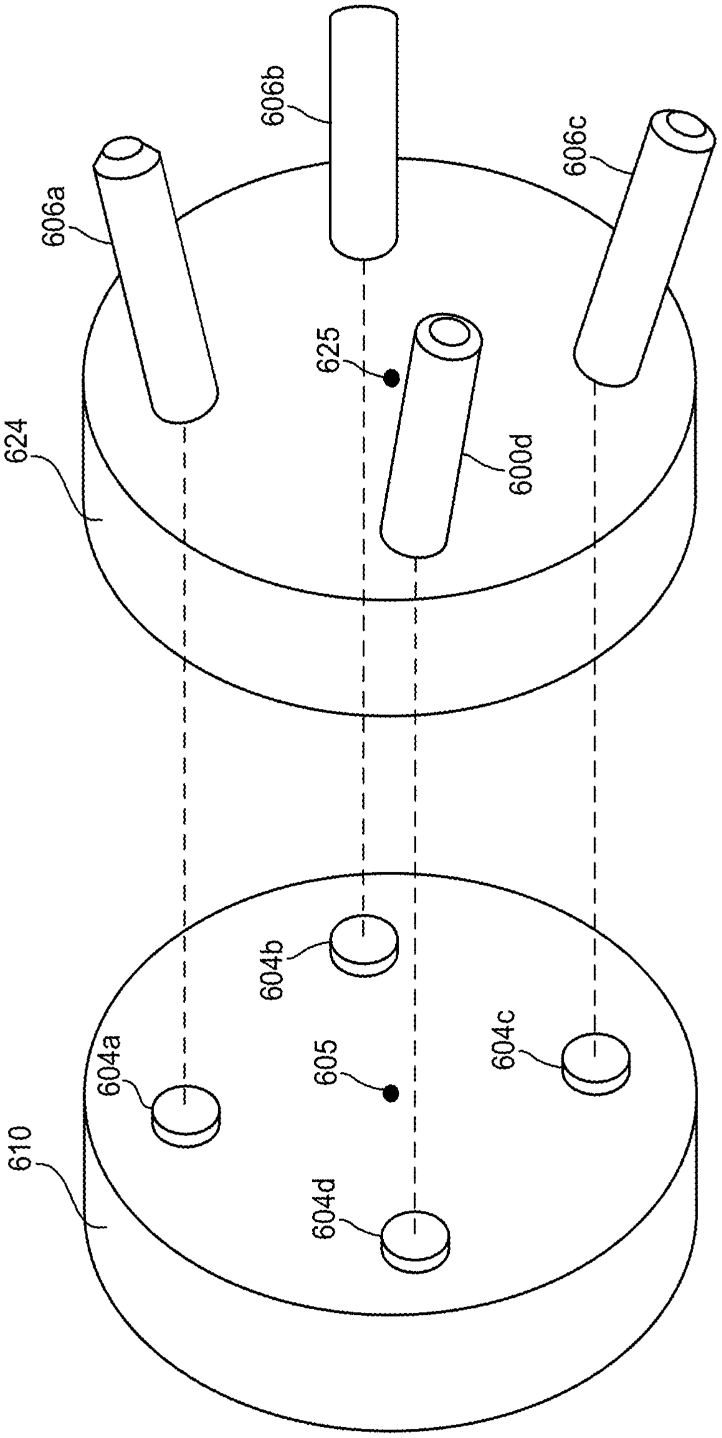


FIG. 6

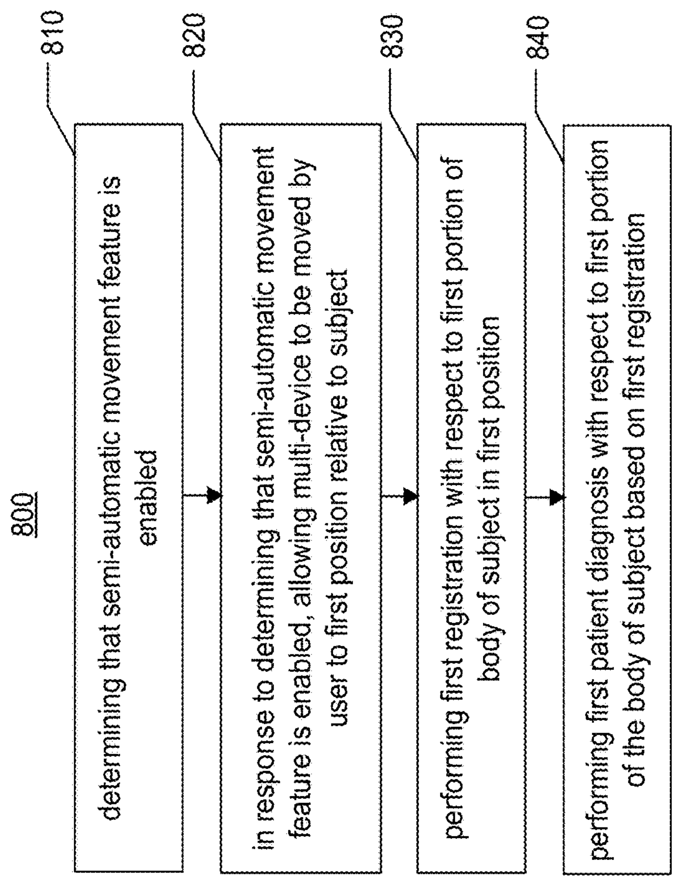

800
810
determining that semi-automatic movement feature is enabled
820
in response to determining that semi-automatic movement feature is enabled, allowing multi-device to be moved by user to first position relative to subject
830
performing first registration with respect to first portion of body of subject in first position
840
performing first patient diagnosis with respect to first portion of the body of subject based on first registration

FIG. 8

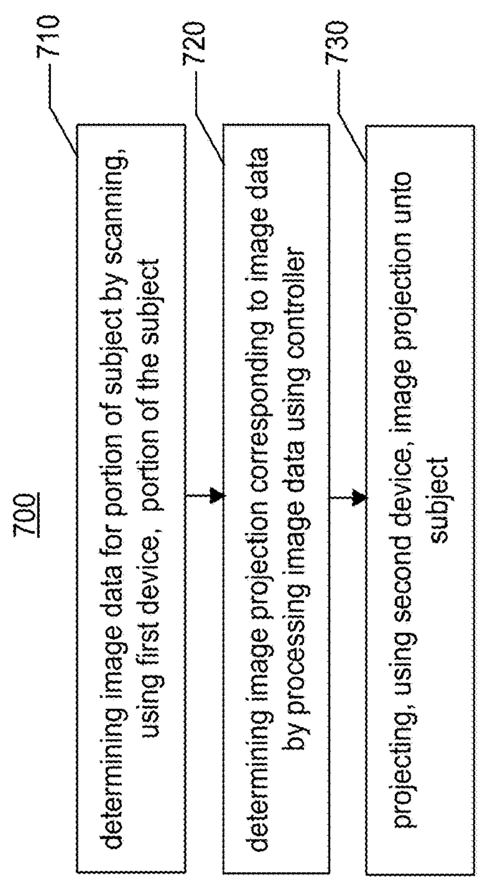

700
710
determining image data for portion of subject by scanning, using first device, portion of the subject
720
determining image projection corresponding to image data by processing image data using controller
730
projecting, using second device, image projection unto subject

FIG. 7

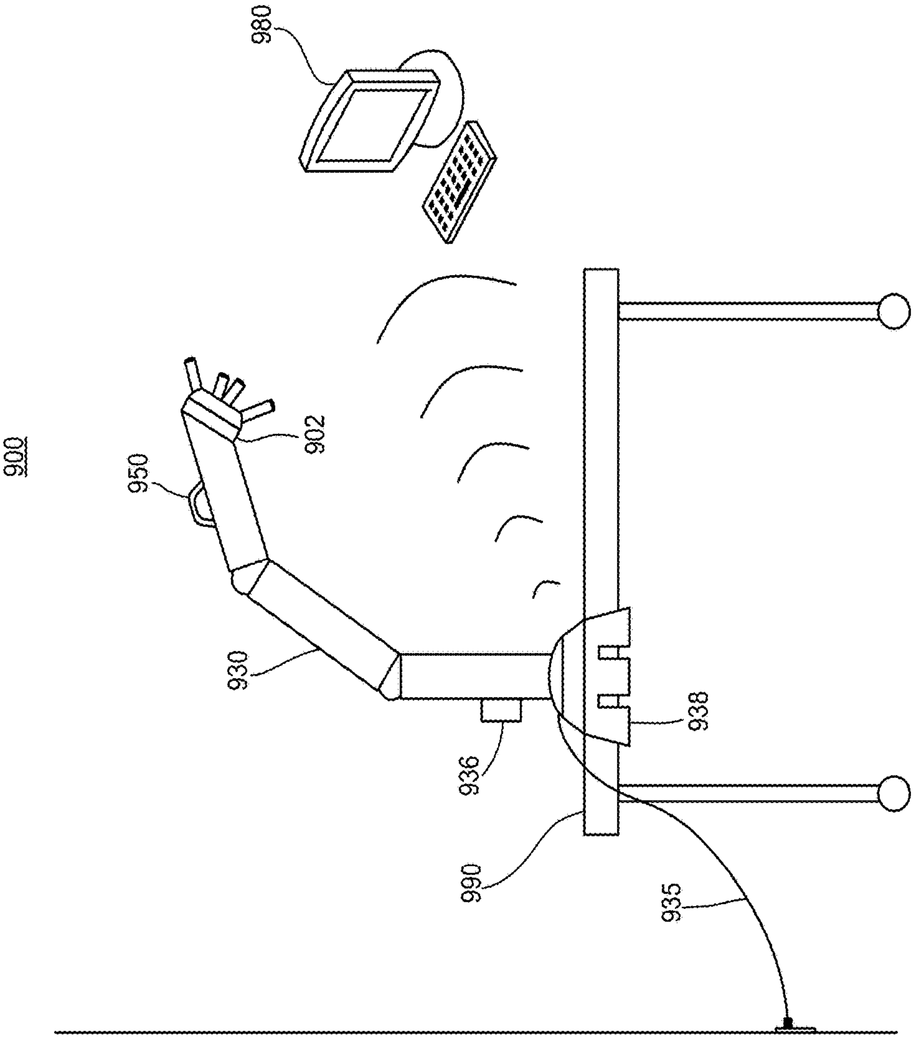


FIG. 9

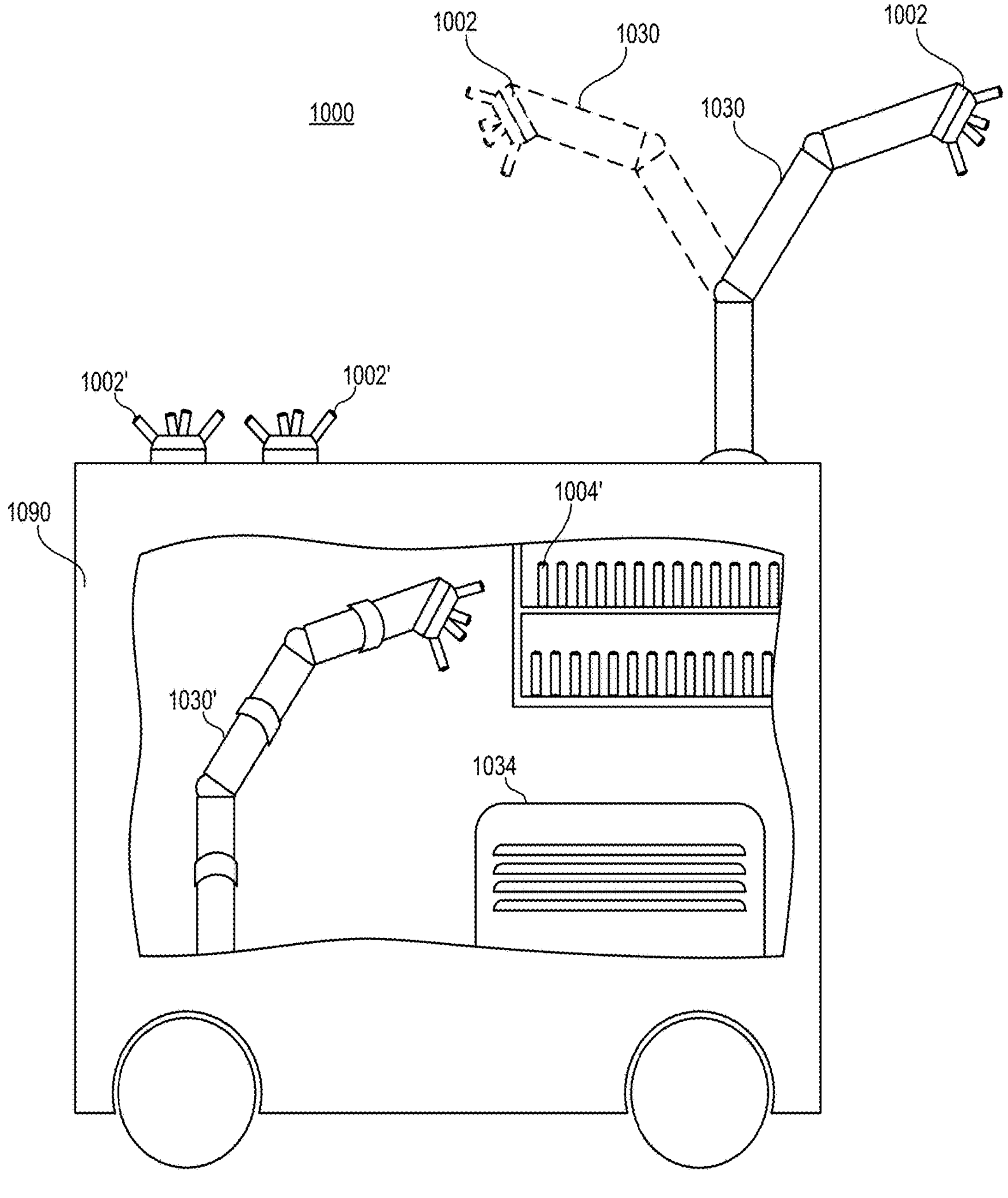


FIG. 10

MULTI-DEVICE SYSTEM

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of and priority to U.S. provisional patent application Ser. No. 62/544,362, filed Aug. 11, 2017, the contents of which are incorporated herein by reference in its entirety.

BACKGROUND

[0002] To provide more efficient and effective healthcare, a variety of different medical devices can be utilized to diagnose and treat a subject (e.g., a patient). For example, if the subject is experiencing health problems that are not readily diagnosable, a variety of imaging and diagnosing devices can assist a healthcare provider in determining the undiagnosed condition. However, use of multiple different medical devices can be cumbersome and even impractical for a healthcare provider, especially in an emergency situation where time of diagnosing and administering treatment to a subject is critical for the subject's health. In addition, these medical devices often are operated by highly skilled technicians, thus further complicating the administration of healthcare.

SUMMARY

[0003] According to various arrangements, a multi-device system can provide efficient and effective healthcare administration such that a highly skilled technician is not needed to operate the multi-device system. For example, the multi-device system can readily provide multiple different imaging and physiological scanning devices for implementation with respect to a subject (e.g., a patient, an animal, and the like), as the multi-device system can easily toggle between the different devices. Therefore, more efficient and effective administration of healthcare can be provided by the automation achieved by the multi-device system.

[0004] In some arrangements, a multi-device system for providing healthcare to a subject includes a multi-device, which includes a body interface and a plurality of devices fixed to the body interface. Each of the plurality of devices configured to collect data of or provide therapy to the subject. The multi-device system further includes a body operatively coupled to the multi-device at the body interface. The body is configured to position the multi-device with respect to the subject. The body interface is configured to move relative to the body to selectively activate at least one of the plurality of devices.

[0005] In some arrangements, each of the plurality of devices is configured to collect data of the subject and includes at least one of a camera, an ultrasound range device, an ultrasound imaging device, a thermal imaging device, a near-infrared imaging device, a near-infrared spectroscopy device, an optical camera device, a lighting device, a spectrometer device, a microphone device, an electroencephalography device, and a metal detector.

[0006] In some arrangements, each of the plurality of devices is configured to provide therapy to the subject and includes at least one of a laser, a syringe, an ablation device, a light therapy device, an electric shock therapy device, a stitching device, a scalpel, a catheter, an insulin pump, a bandaging device, and a respirator.

[0007] In some arrangements, the multi-device system of claim **1** further includes a power supply configured to provide power to the plurality of devices and a controller configured to transmit operational instructions to the plurality of devices and receive the data collected by the plurality of devices. The at least one of the plurality of devices is activated when the at least one of the plurality of devices is receiving the power and the operational instructions.

[0008] In some arrangements, the body interface includes a first connection interface operatively coupled to each of the plurality of devices. The body includes a second connection interface operatively coupled to the power supply and the controller. The second connection interface is configured to provide the power and the operational instructions to the first connection interface for the activated at least one of the plurality of devices by operatively coupling to the first connection interface when the body interface is moved relative to the body to a predetermined position. The first connection interface is configured to provide the data collected by the at least one of the plurality of devices to the second connection interface by operatively coupling to the second connection interface.

[0009] In some arrangements, the first connection interface for the at least one of the plurality of devices includes a first power interface and a first data communication interface separate from the first power interface. The second connection interface includes a second power interface and a second data communication interface separate from the second power interface. The second power interface is configured to operatively couple to the first power interface when the body interface is moved relative to the body to the predetermined position to provide the power to the first power interface. The second data communication interface is configured to operatively couple to the first data communication interface when the body interface is moved relative to the body to the predetermined position to provide the operational instructions to the first data communication interface and to receive the data collected by the activated at least one of the plurality of devices from the first data communication interface.

[0010] In some arrangements, the second connection interface is configured to provide the power and the operational instructions to the first connection interface by providing to the first connection interface modulated power signals includes the power from the power supply and the operational instructions from the controller.

[0011] In some arrangements, the body interface includes a locking device configured to structurally maintain the predetermine position.

[0012] In some arrangements, the body interface includes a first connection interface operatively coupled to each of the plurality of devices. The body includes a second connection interface operatively coupled to the power supply and the controller. The second connection interface includes at least one data transmission ring configured to receive the data collected by the at least one of the plurality of devices.

[0013] In some arrangements, the body interface being configured to move relative to the body to selectively activate at least one of the plurality of devices by: responsive to the body interface being moved relative to the body to a first predetermined position, a first device of the plurality of devices is activated while a second device of the plurality of devices is inactivated; and responsive to the body interface being moved relative to the body to a second predetermined position, the second device is activated while the first device is inactivated.

[0014] In some arrangements, the body interface is configured to rotate relative to the body to selectively activate the at least one of the plurality of devices.

[0015] In some arrangements, the at least one of the plurality of devices includes a force controller configured to determine a force exerted by the at least one of the plurality of devices against the subject.

[0016] In some arrangements, the multi-device further includes a plurality of tools. The plurality of tools is configured to move relative to the plurality of devices. The first tool of the plurality of tools is configured to operatively couple to one of the at least one of the plurality of devices when the plurality of tools is moved to a first relative position relative to the plurality of devices. The first tool being operatively coupled to the one of the at least one of the plurality of devices enables the one of the at least one of the plurality of devices to output first data. A second tool of the plurality of tools is configured to operatively couple to the one of the at least one of the plurality of devices when the plurality of tools is moved to a second relative position relative to the plurality of devices. The second tool being operatively coupled to the one of the at least one of the plurality of devices enables the one of the at least one of the plurality of devices to output second data different from first data.

[0017] In some arrangements, the one of the plurality of devices is one of a photo-sensor, an infrared sensor, a particle detector, and a laser emitter. Each of the plurality of tools is at least one of a lens, a photo-projector, and a waveguide.

[0018] In some arrangements, the one of the plurality of devices is a photo-sensor. The first tool is a wide-angle lens. The first data include first image data capturing a first portion of the subject. The second tool is a zoom lens. The second data include second image data capturing a second portion of the subject. The first portion is larger than the second portion.

[0019] In some arrangements, another one of the plurality of devices is a laser emitter. The plurality of tools includes a grid lens configured to be operatively coupled to the laser emitter in the first relative position. The laser emitter is configured to project a grid onto the subject while the first data is being collected by the photo-sensor through the wide-angle lens or while the second data is being collected by the photo-sensor through the zoom lens.

[0020] In some arrangements, the body includes a robotic manipulator having at least two arm segments and a joint. The robotic manipulator is configured to position the multi-device with respect to the subject.

[0021] In some arrangements, the body further includes at least one of a mounting mechanism configured to detachably mount the multi-device system to an object, a battery, and a network device.

[0022] In some arrangements, the body further includes a manual interface configured to allow the multi-device to be moved relative to the subject by a user of the multi-device system.

[0023] In some arrangements, the body further includes a semi-automatic switch. The semi-automatic switch being in a first state corresponds to allowing the multi-device to be moved relative to the subject by the user via the manual interface. The semi-automatic switch being in a second state corresponds to disallowing the multi-device to be moved relative to the subject by the user.

[0024] In some arrangements, a method for providing healthcare to a subject using a multi-device system, the method includes providing a multi-device that includes a body interface and a plurality of devices fixed to the body interface, wherein each of the plurality of devices is configured to provide healthcare to the subject by collecting data. The method further includes providing a body operatively coupled to the multi-device at the body interface. The body is configured to position the multi-device with respect to the subject. The body interface is configured to move relative to the body to selectively activate at least one of the plurality of devices.

[0025] In some arrangements, the method further includes providing a plurality of tools. The plurality of tools is configured to move relative to the plurality of devices. A first tool of the plurality of tools is configured to operatively couple to a first device of the at least one of the plurality of devices when the plurality of tools is moved to a first relative position relative to the plurality of devices. The first tool being operatively coupled to the first device enables the first device to output first data. A second tool of the plurality of tools is configured to operatively couple to the first device when the plurality of tools is moved to a second relative position relative to the plurality of devices. The second tool being operatively coupled to the first device enables the first device to output second data different from first data.

[0026] In some arrangements, the first device and a second device of the at least one of the plurality of devices are configured to be activated simultaneously.

[0027] In some arrangements, a third tool of the plurality of tools is configured to operatively couple to the second device when the plurality of tools is moved to the first relative position relative to the plurality of devices.

[0028] In some arrangements, the first device is a photo-sensor. The first tool is a wide-angle lens. The second device is a laser emitter. The second tool is a grid lens.

[0029] In some arrangements, a method for providing healthcare to a subject using multi-device system having a multi-device and a body configured to move the multi-device relative to the subject includes determining that a semi-automatic movement feature is enabled, in response to determining that the semi-automatic movement feature is enabled, allowing the multi-device to be moved by a user to a first position relative to the subject, performing first registration with respect to a first portion of a body of the subject in the first position, and performing first subject imaging with respect to the first portion of the body of the subject based on the first registration.

[0030] In some arrangements, allowing the multi-device to be moved relative to the subject by the user includes providing a manual interface on the body or the multi-device, wherein the manual interface is configured to interact with the user to allow the user to move the multi-device, and enabling the user to move the multi-device by loosening one or more joints on the body.

[0031] In some arrangements, the method further includes allowing the multi-device to be moved by the user to a second position relative to the subject, performing second registration with respect to a second portion of a body of the subject in the second position, and performing second subject imaging with respect to the second portion of the body of the subject based on the second registration.

[0032] In some arrangements, the first portion is larger in size than the second portion.

[0033] In some arrangements, the first portion and the second portion correspond to different body parts of the subject.

[0034] In some arrangements, a method for providing healthcare to a subject using a multi-device system having a controller, a multi-device, and a body configured to move the multi-device relative to the subject, the multi-device having a first device and a second device, the method includes determining imaging data for a portion of the subject by scanning, using the first device, the portion of the subject, determining image projection corresponding to the imaging data by processing the imaging data using the controller, and projecting, using the second device, the image projection unto the subject.

[0035] In some arrangements, the image projection is projected using the second device unto the portion of the subject or a different portion of the subject.

[0036] In some arrangements, the method further includes performing registration with respect to the portion of the subject using a third device of the multi-device, wherein the imaging data is generated based on the registration.

BRIEF DESCRIPTION OF THE FIGURES

[0037] Features, aspects, and advantages of the present invention will become apparent from the following description and the accompanying example arrangements shown in the drawings, which are briefly described below.

[0038] FIG. **1** is a system block diagram illustrating an example of a multi-device system according to various arrangements.

[0039] FIG. **2**A illustrates a front view of a multi-device according to various arrangements.

[0040] FIG. **2**B illustrates a perspective view of the multi-device shown in FIG. **2**A according to various arrangements.

[0041] FIG. **2**C illustrates a side view of the multi-device shown in FIG. **2**A according to various arrangements.

[0042] FIG. **2**D illustrates a rear view of the multi-device shown in FIG. **2**A according to various arrangements.

[0043] FIG. **2**E illustrates a side view of the multi-device shown in FIG. **2**A according to various arrangements.

[0044] FIG. **2**F illustrates a perspective view of the multi-device shown in FIG. **2**A according to various arrangements.

[0045] FIG. **2**G illustrates a perspective view of the multi-device shown in FIG. **2**A according to various arrangements.

[0046] FIG. **2**H illustrates a perspective view of the multi-device shown in FIG. **2**A according to various arrangements.

[0047] FIG. **3**A illustrates a perspective view of a multi-device system according to various arrangements.

[0048] FIG. **3**B illustrates a front view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0049] FIG. **3**C illustrates a side view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0050] FIG. **3**D illustrates a top view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0051] FIG. **3**E illustrates a side view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0052] FIG. **3**F illustrates an overhead view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0053] FIG. **3**G illustrates a rear view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0054] FIG. **3**H illustrates a bottom view of the multi-device system shown in FIG. **3**A according to various arrangements.

[0055] FIG. **4**A illustrates a first connection interface of a body interface of a multi-device according to various arrangements.

[0056] FIG. **4**B illustrates a second connection interface of a body according to various arrangements.

[0057] FIG. **5**A illustrates a first connection interface of a body interface of a multi-device according to various arrangements.

[0058] FIG. **5**B illustrates a second connection interface of a body according to various arrangements.

[0059] FIG. **6** illustrates tools being operatively coupled to devices according to various arrangements.

[0060] FIG. **7** is a flow diagram illustrating a method for using a multi-device system according to various arrangements.

[0061] FIG. **8** is a flow diagram illustrating a method for using a multi-device system according to various arrangements.

[0062] FIG. **9** illustrates an example implementation of a multi-device system according to various arrangements.

[0063] FIG. **10** illustrates an example implementation of a multi-device system according to various arrangements.

DETAILED DESCRIPTION

[0064] The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well-known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

[0065] In the following description of various arrangements, reference is made to the accompanying drawings which form a part hereof and in which are shown, by way of illustration, specific arrangements in which the arrangements may be practiced. It is to be understood that other arrangements may be utilized, and structural changes may be made without departing from the scope of the various arrangements disclosed in the present disclosure.

[0066] As referred to herein, healthcare and the provision thereof refer to one or more of improving, maintaining, and restoring of a subject's health through monitoring, diagnosis, treatment, or another suitable medical procedure. In some examples, the devices, tools, sensors, instruments, apparatuses, systems, and the like are configured to provide healthcare to a subject (e.g., a human patient, an animal, and the like), as described herein.

[0067] FIG. **1** is a system block diagram illustrating an example of a multi-device system **100** according to various arrangements. Referring to FIG. **1**, the multi-device system **100** is configured to provide healthcare to a subject, by autonomously or automatically operating a variety of devices **104***a*-**104***n* and tools **106***a*-**106***n* to monitor, diagnose, treat, or perform another suitable medical procedure on a subject. The multi-device system **100** is shown to include at least a multi-device **102** and a body **130**.

[0068] The multi-device **102** includes multiple devices (e.g., devices **104***a*-**104***n*). While the multi-device **102** is shown to include the devices **104***a*-**104***n*, one of ordinary skill in the art can appreciate that the multi-device **102** may have any number of two or more devices disposed thereon. Each of the devices **104***a*-**104***n* is configured to collect data (e.g., physiological data, biometric data, imaging data, and the like) of a subject. In that regard, each of the devices **104***a*-**104***n* is or includes at least one of a camera, an ultrasound range device, an ultrasound imaging device, a thermal imaging device, a near-infrared imaging device, a near-infrared spectroscopy device, an optical camera device, a lighting device, a spectrometer device, a microphone device, an electroencephalography device, a metal detector, and any other similar data-gathering device.

[0069] The multi-device **102** includes a body interface **110**. The devices **104***a*-**104***n* are fixed, attached, mounted, or otherwise disposed on the body interface **110**, such that the devices **104***a*-**104***n* can move with the body interface **110**. In some arrangements, the devices **104***a*-**104***n* are detachably mounted to the body interface **110**, such that one or more of the devices **104***a*-**104***n* can be detached and replaced with other devices or other types of devices. In some arrangements, the devices **104***a*-**104***n* are fixed to the body interface **110** such that the devices **104***a*-**104***n* are immobile relative to the body interface **110**. In some arrangements, the body interface **110** further comprises mechanical actuators (not shown) configured to move (e.g., extend, re-orient, or rotate) one or more of the devices **104***a*-**104***n* in one to six degrees-of-freedom (DOFs) relative to the body interface **110** to enable movement of the one or more of the devices **104***a*-**104***n* relative to the body interface **110** during data collection. Each mechanical actuator can enable at least one of a linear actuation in the Cartesian system, swivel, sweep, pitch, roll, yaw, and the like. The devices **104***a*-**104***n* are spaced apart from one another in some arrangements to avoid interference during the operations of the devices **104***a*-**104***n*.

[0070] The body **130** is configured to position the multi-device **102** (e.g., to position the devices **104***a*-**104***n* and the tools **106***a*-**106***n*) with respect to a subject. For example, the body **130** includes a robotic manipulator or arm configured to position the multi-device **102** with respect to the subject. In that regard, the robotic manipulator includes arm segments (e.g., at least two arm segments) and joints, each of which connect two arm segments. Each joint is configured to enable one arm segment to move in up to six DOFs (e.g., in at least one of linear actuation in the Cartesian system, swivel, sweep, pitch, roll, yaw, and the like) relative to another arm segment or relative to a platform/base. In that regard, the arm segments and the joints define a workspace or a work envelope for the robotic manipulator. The robotic manipulator can be implemented in any suitable manner to correspond to the operations of the devices **104***a*-**104***n* and the tools **106***a*-**106***n*.

[0071] The body **130** is configured to be operatively coupled to the multi-device **102** at the body interface **110**. The multi-device **102** can be movably supported by the body **130** via the body interface **110**. For example, the body interface **110** includes a movement mechanism **120** configured to move the body interface **110** and the entire multi-device **102** relative to the body **130**. Particularly, the movement mechanism **120** is configured to move the body interface **110** and the entire multi-device **102** relative to an end of the body **130** that is operatively coupled to the body interface **110**. In that regard, the movement mechanism **120** is a mechanical joint that enables the body interface **110** to move in up to six DOFs (e.g., in at least one of linear actuation in the Cartesian system, swivel, sweep, pitch, roll, yaw, and the like) relative to the end of the body **130** that is operatively coupled to the body interface **110**. For example, the movement mechanism **120** may include a motor assembly to move the body interface **110** relative to the body **130**. Alternatively, instead of disposing the movement mechanism **120** on the body interface **110**, a movement mechanism similar to that described herein can be disposed on the body **130** to move the end of the body **130** operatively coupled to the body interface **110** relative to the body interface **110**.

[0072] In some arrangements, the body interface **110** (and the entire multi-device **102**) is detachably mounted to the body **130**, such that the multi-device **102** can be detached and replaced with another multi-device.

[0073] The multi-device system **100** (e.g., the body **130**) includes a power supply **134** configured to provide power to the devices **104***a*-**104***n*, the tools **106***a*-**106***n*, the movement mechanism **120**, and other components of the multi-device **102** that need power to operate, in the manner described. The power supply **134** can further provider power to various components (e.g., a network device **136**, a controller **132**, and the like) of the body **130**. The power supply **134** is one or more of one or more of batteries (e.g., lithium-polymer batteries), solar panels/cells, hydrogen cells, tethered power connections, combustion engines, power links (e.g., laser transmitter), or the like.

[0074] The multi-device system **100** (e.g., the body **130**) includes a controller **132** configured to generate, transmit, or otherwise provide operational instructions to the devices **104***a*-**104***n*, the tools **106***a*-**106***n*, the movement mechanism **120**, and other components of the multi-device **102** that need the operational instructions to operate, in the manner described. The controller **132** is further configured to control the movement of the body **130** (e.g., the robotic manipulator) to position the multi-device **102** relative to the subject. The controller **132** is further configured to receive and process the data collected by the devices **104***a*-**104***n* for diagnosis or for generating additional operational instructions. The additional operational instructions include operational instructions corresponding to further movements of the body **130** (e.g., the robotic manipulator) to further position the multi-device **102** relative to the subject, operational instructions corresponding to further movement of the movement mechanism **120**, and operational instructions for the devices **104***a*-**104***n* and tools **106***a*-**106***n*.

[0075] The controller **132** includes a processor and a memory for performing the functions described herein. The processor may be implemented as a general-purpose processor, an Application Specific Integrated Circuit (ASIC), one or more Field Programmable Gate Arrays (FPGAs), a Digital Signal Processor (DSP), a group of processing components, or other suitable electronic processing components. The memory (e.g., Random Access Memory (RAM), Read-Only Memory (ROM), Non-volatile RAM (NVRAM), Flash Memory, hard disk storage, etc.) stores data and/or computer code for facilitating at least some of the various processes described herein. The memory includes tangible, non-transient volatile memory, or non-volatile memory. In this regard, the memory stores programming logic that, when executed by the processor, controls the operations of the body **130** and the multi-device **102** in the manner described herein.

[0076] In some arrangements, a device (e.g., the device **104***n*) includes a force controller (e.g., a force controller **103**) configured to detect the reactionary force that a surface (e.g., skin of a subject) exerts against the device as the device monitors, diagnoses, treats, or performs another suitable medical procedure on the subject. For example, the force controller **103** can be positioned behind or directly behind an activation slot of the device **104***n*. Alternatively, the force controller **103** can be positioned behind or directly behind an activation slot of the multi-device **102**. The force controller **103** can be positioned between the device **104***a* and the body interface **110**. A load cell can be positioned behind the activation slot for detecting an amount of reactionary force that a surface exerts against the activated device **104***n* as the activated device **104***n* exerts an opposite force against the surface. In an example in which the device **104***n*, when activated, utilizes physical contact against a subject for operation (e.g., an ultrasound imaging device or a Transcranial Doppler (TCD) device), the force controller **103** can detect an amount of force exerted by the surface against the device **104***n*. The data corresponding to the detected force can be sent by the force controller **103** to the first data communication interface **114**, to be sent to the controller **132** for processing in the manner similar to described with respect to the data collected by the device **104***n*. Based on the detected force, the multi-device system **100** (e.g., the controller **132**) can regulate the force that the activated device **104***n* exerts against the subject so that the device **104***n* is not causing pain to the subject or to ensure that the device **104***n* is pressed against the subject using an adequate amount of force so that the device **104***n* can adequately perform operations.

[0077] In some arrangements, the body interface **110** is configured to move relative to the body **130** to selectively activate at least one of the devices **104***a*-**104***n* at a given time. In that regard, the movement mechanism **120** or another suitable movement mechanism can be configured to selectively activate at least one of the devices **104***a*-**104***n* by moving the body interface **110** with respect to the body **130**. The at least one of the devices **104***a*-**104***n* is activated when the at least one of the devices **104***a*-**104***n* is receiving the power and the operational instructions from the body **130**.

[0078] In that regard, the body interface includes a first connection interface **112** operatively coupled to each of devices **104***a*-**104***n*. The body **130** includes a second connection interface **140** operatively coupled to the power supply **134** and the controller **132**. The second connection interface **140** is configured to provide the power and the operational instructions to the first connection interface **112** for the activated at least one of the devices **104***a*-**104***n* by operatively coupling to the first connection interface **112** when the body interface **110** is moved (e.g., rotated) relative to the body to a predetermined position. The first connection interface **112** is configured to provide the data collected by the at least one of the devices **104***a*-**104***n* to the second connection interface **140** by operatively coupling to the second connection interface **140**.

[0079] In some examples as shown, the first connection interface **112** includes a first power interface **118** and a first data communication interface **114** separate from the first power interface **118**. The second connection interface **140** includes a second power interface **144** and a second data communication interface **142** separate from the second power interface **144**.

[0080] The power supply **134** is operatively coupled to the second power interface **144**. The second power interface **144** is configured to operatively couple to the first power interface **118** when the body interface **110** is moved relative to the body **130** to the predetermined position to provide the power received from the power supply **134** to the first power interface **118**. The second power interface **144** includes a suitable wire or cable that connects the power supply **134** to the end of the body **130** (e.g., at the second connection interface **140**). The second power interface **144** includes a contact interface (e.g., a metal surface, a metal contact point, or the like). The first power interface **118** includes a contact interface corresponding to each of the devices **104***a*-**104***n*.

[0081] When the body interface **110** (e.g., the first connection interface **112**) is moved (e.g., rotated) to a first predetermined position relative to the end of the body **130** (e.g., the second connection interface **140**), a first contact interface of the first power interface **118** that corresponds to the device **104***a* comes in contact with the contact interface of the second power interface **144**. In other words, the first contact interface of the first power interface **118** and the contact interface of the second power interface **144** are aligned in the first predetermined position. Responsive to the contact and the alignment, the first contact interface of the first power interface **118** is receiving power from the contact interface of the second power interface **144**.

[0082] When the body interface **110** (e.g., the first connection interface **112**) is moved (e.g., rotated) to a second predetermined position relative to the end of the body **130** (e.g., the second connection interface **140**), another contact interface of the first power interface **118** that corresponds to another device (e.g., the device **104***b*) comes in contact with the contact interface of the second power interface **144**. In other words, the another contact interface of the first power interface **118** and the contact interface of the second power interface **144** are aligned in the second predetermined position. Responsive to the contact and the alignment, the another contact interface of the first power interface **118** is receiving power from the contact interface of the second power interface **144**.

[0083] The controller **132** is operatively coupled to the second data communication interface **142**. The second data communication interface **142** is configured to operatively couple to the first data communication interface **114** when the body interface **110** is moved relative to the body **130** to the predetermined position to provide the operational instructions to the first data communication interface **114** and to receive the data collected by the at least one of the devices **104***a*-**104***n* from the first data communication interface **114**. The second data communication interface **142** includes a suitable wire or cable that connects the controller **132** to the end of the body **130** (e.g., at the second connection interface **140**). The second data communication interface **142** includes a contact interface (e.g., a metal surface, a metal contact point, or the like). The first data communication interface **114** includes a contact interface corresponding to each of the devices **104***a*-**104***n*.

[0084] When the body interface **110** (e.g., the first connection interface **112**) is moved (e.g., rotated) to a first predetermined position relative to the end of the body **130** (e.g., the second connection interface **140**), a first contact interface of the first data communication interface **114** that corresponds to the device **104***a* comes in contact with the contact interface of the second data communication interface **142**. In other words, the first contact interface of the first data communication interface **114** and the contact interface of the second data communication interface **142** are aligned in the first predetermined position. Responsive to the contact and the alignment, the first contact interface of the first data communication interface **114** is receiving operational instructions from the contact interface of the second data communication interface **142**, and the first contact interface of the first data communication interface **114** is sending captured data to the contact interface of the second data communication interface **142**.

[0085] When the body interface **110** (e.g., the first connection interface **112**) is moved (e.g., rotated) to a second predetermined position relative to the end of the body **130** (e.g., the second connection interface **140**), another contact interface of the first data communication interface **114** that corresponds to another device (e.g., the device **104***b*) comes in contact with the contact interface of the second data communication interface **142**. In other words, the another contact interface of the first data communication interface **114** and the contact interface of the second data communication interface **142** are aligned in the second predetermined position. Responsive to the contact and the alignment, the another contact interface of the first data communication interface **114** is receiving power from the contact interface of the second data communication interface **142**, and the another contact interface of the first data communication interface **114** is sending captured data to the contact interface of the second data communication interface **142**.

[0086] In some examples, when the body interface **110** (e.g., the first connection interface **112**) is moved (e.g., rotated) to a first predetermined position relative to the end of the body **130** (e.g., the second connection interface **140**), a first contact interface of the first power interface **118** that corresponds to the device **104***a* comes in contact with the contact interface of the second power interface **144**, and a first contact interface of the first data communication interface **114** that corresponds to the device **104***a* comes in contact with the contact interface of the second data communication interface **142**. That is, when the body interface **110** is moved to a first predetermined position relative to the end of the body **130**, the device **104***a* is receiving both power and operational instructions from the second data communication interface **142** and the second power interface **144**. The device **104***a* is also sending captured data to the second data communication interface **142**. Therefore, the device **104** is deemed to be activated when the body interface **110** is moved to the first predetermined position.

[0087] In some arrangements, when the body interface **110** is moved to a predetermined position relative to the end of the body **130**, one of the devices **104***a*-**104***n* is activated in the manner described.

[0088] In other arrangements, when the body interface **110** is moved to a predetermined position relative to the end of the body **130**, two or more of the devices **104***a*-**104***n* are simultaneously activated in the manner described. For example, instead of one contact, each of the second data communication interface **142** and the second power interface **144** may have multiple contacts disposed on the second connection interface **140**. Multiple contacts corresponding to two or more of the devices **104***a*-**104***n* are disposed on each of the first data communication interface **114** and the first power interface **118**. When the body interface **110** is moved to the predetermined position relative to the end of the body **130**, the multiple contacts of the second data communication interface **142** contacts and aligns with the multiple contacts of the first data communication interface **114**, and the multiple contacts of the second power interface **144** contacts and aligns with the multiple contacts of the first power interface **118**. This allows multiple ones of the devices **104***a*-**104***n* to be simultaneously activated, to perform a joint task or to obtain data of the subject simultaneously.

[0089] In some arrangements, instead of two separate links (e.g., contacts) for power and data/operational instructions, the first connection interface **112** and the second connection interface **140** can transfer power and data/operational instructions via a same link. For example, the second connection interface **140** is configured to provide the power and the operational instructions to the first connection interface **112** by providing to the first connection interface **112** modulated power signals that include the power from the power supply **134** and the operational instructions from the controller **132**. In that regard, the second connection interface **140** includes a modulator that modulates the operational instructions with the power. The first connection interface **112** includes a demodulator that demodulates the modulated power signals to separate the power signals from the operational instructions. The first connection interface **112** and the second connection interface **140** each includes a contact, such that when the contacts are in contact with and align one another, the modulated power signals are communicated from the second connection interface **140** to the first connection interface **112**.

[0090] In some arrangements, instead of a physical contact connection, the first connection interface **112** and the second connection interface **140** can communicate power and data/operational instructions wirelessly. With respect to power, each of the first power interface **118** and the second power interface **144** includes a loop or coil configured to communicate power wirelessly via induction. With respect to data/operational instructions, each of the first data communication interface **114** and the second data communication interface **142** includes suitable network device configured to communicate wireless signals via Bluetooth®, Wi-Fi, cellular, or another suitable wireless network. In the implementations in which modulated power signals are implemented, the first connection interface **112** and the second connection interface **140** each includes a loop or coil configured to communicate the modulated power signals via induction.

[0091] In some arrangements, the multi-device **102** may include its own power supply (e.g., a rechargeable battery) such that any electrical connection between the body **130** and the multi-device **102** is not necessary.

[0092] In some arrangements, the body interface **110** includes a locking device **122** configured to structurally maintain a predetermine position to maintain connection. The locking device **122** may include one or more of magnets, spring-loaded pins, clamps, locks, latches, bolts, buckles, clips, hook-and-look fasteners, pegs, pins, rivets, snap fasteners, straps, and another suitable mechanical fastener.

Alternatively or additionally, another locking device (such as but not limited to, the locking device **122**) can be disposed on the body **130** (e.g., on the second connection interface **140**). In one example, the contact interfaces described herein can include magnets, or magnets are disposed in or around the contact interfaces such that magnetic force maintains the relative positions of the body and the body interface **110**. In that regard, the magnets for a contact interface in the body interface **110** have the opposite polarity as compared to the magnets for a contact interface in the body **130**.

[0093] In some arrangements, the second data communication interface **144** may include data transmission component (e.g., a fiber optics ring) configured to receive data from the activated ones of the devices **104***a*-**104***n*. The first data communication interface **114** includes a component corresponding to each of the devices **104***a*-**104***n*. The component can fire the collected data onto the fiber optics ring. The fiber optics ring can then relay the data to the controller **132**. This enables one or more activated ones of the devices **104***a*-**104***n* to send data to the second data communication interface **144** regardless of a position of the body interface **110** relative to the body **130**. This further enables multiple activated devices to send data to the second data communication interface **144** simultaneously.

[0094] Any number of combination of the examples described herein relating to transfer of power, operational instructions, and data can be implemented by the body interface **110** (the first connection interface **112**) and the second connection interface **140**.

[0095] In some arrangements, a device (e.g., the device **104***n*) includes a force controller (e.g., a force controller **103**) configured to detect the reactionary force that a surface (e.g., skin of a subject) exerts against the device as the device monitors, diagnoses, treats, or performs another suitable medical procedure on the subject. For example, the force controller **103** can be positioned behind or directly behind an activation slot of the device **104***n*. Alternatively, the force controller **103** can be positioned behind or directly behind an activation slot of the multi-device **102**. The force controller **103** can be positioned between the device **104***a* and the body interface **110**. A load cell can be positioned behind the activation slot for detecting an amount of reactionary force that a surface exerts against the activated device **104***n* as the activated device **104***n* exerts an opposite force against the surface. In an example in which the device **104***n*, when activated, utilizes physical contact against a subject for operation (e.g., an ultrasound imaging device or a Transcranial Doppler (TCD) device), the force controller **103** can detect an amount of force exerted by the surface against the device **104***n*. The data corresponding to the detected force can be sent by the force controller **103** to the first data communication interface **114**, to be sent to the controller **132** for processing in the manner similar to described with respect to the data collected by the device **104***n*. Based on the detected force, the multi-device system **100** (e.g., the controller **132**) can regulate the force that the activated device **104***n* exerts against the subject so that the device **104***n* is not causing pain to the subject or to ensure that the device **104***n* is pressed against the subject using an adequate amount of force so that the device **104***n* can adequately perform operations.

[0096] In some arrangements, the body **130** includes a network device **136** configured to receive data from another computing platform and/or send data to another computing platform. For example, the network device **136** can be configured to receive the operational instructions from a computing platform, which includes a user interface configured to receive the operational instructions or instructions to control the movement of the body **130** (e.g., the robotic manipulator) from a healthcare provider. The network device **136** can be further configured to send the data collected by the devices **104***a*-**104***n* to the computing platform. The computing platform can process the data for diagnosis or for generating additional operational instructions. The network device **136** includes at least one transceiver that performs transmit/receive functions via Bluetooth®, Wi-Fi, cellular, or another suitable wireless network. The network device **136** can include separate transmit and receive circuitries, or can include a transceiver that combines transmitter and receiver functions.

[0097] In some arrangements, the body **130** includes a mounting mechanism **138** configured to detachably mount the multi-device system **100** (e.g., the body **130**) to an object. For example, the mounting mechanism **138** can be configured to anchor the body **130** on a surface (e.g., a table, a bed, a gurney, a stretcher, a workbench, a wall, a vehicle, a computing platform or workstation, and the like). The mounting mechanism **138** is disposed on an end of the body **130** (e.g., a robotic manipulator) that is opposite to the end on which the second connection interface **140** is disposed. The mounting mechanism **138** is a mechanical fastener, examples of which include but are not limited to, magnets, spring-loaded pins, clamps, locks, latches, bolts, buckles, clips, hook-and-look fasteners, pegs, pins, rivets, snap fasteners, straps, strings, and another suitable mechanical fastener.

[0098] In some arrangements, the body **130** includes a semi-automatic switch **148** and a manual interface **150**. The manual interface **150** configured to allow the multi-device **102** to be moved relative to the subject by a user (e.g., a healthcare provider) of the multi-device system **100**. In that regard, the manual interface **150** is disposed on one or more of the multi-device **102** or the body **130** to allow the user to move the multi-device **102** and/or the body **130** by moving (e.g., pulling, pushing, dragging, and the like) the manual interface **150**. Examples of the manual interface **150** include but are not limited to, a handle, a knob, a rope, a groove, a grip, and the like.

[0099] The semi-automatic switch **148** being in a first state corresponds to allowing the multi-device **102** and/or the body **130** to be moved relative to the subject by the user via the manual interface **150**. The semi-automatic switch **148** being in a second state corresponds to disallowing the multi-device **102** and/or the body **130** to be moved relative to the subject by the user. The semi-automatic switch **148** can be a type of switch connected to the controller **132**. Responsive to determining that the semi-automatic switch **148** is in the first state, the controller **132** enables the user to move the multi-device **102** by loosening one or more joints on the body **130** (e.g., the robotic manipulator), such that the user can move the manual interface **150** (and therefore the multi-device **102** and/or the body **130**) to a designed position. Responsive to determining that the semi-automatic switch **148** is in the second state, the controller **132** disallows the movement of the multi-device **102** and/or the body **130** by tightening one or more joints on the body **130** (e.g., the robotic manipulator), such that the body **130** and the multi-device **102** are rigid and unresponsive to user manipulation.

[0100] In some arrangements, the tools **106***a*-**106***n* can be selectively coupled to one or more of the devices **104***a*-**104***n* to enhance or change data characteristics of the one or more of the devices **104***a*-**104***n*. While the multi-device **102** is shown to include the tools **106***a*-**106***n*, one of ordinary skill in the art can appreciate that the multi-device **102** may have any number of tools disposed the multi-device **102**. The tools **106***a*-**106***n* are configured to move (e.g., rotate) relative to the devices **104***a*-**104***n* to selectively couple to the one or more of the devices **104***a*-**104***n*. For example, the tools **106***a*-**106***n* are fixed, attached, mounted, or otherwise disposed on a platform **124** (e.g., a disk). The tools **106***a*-**106***n* can rotate with the platform **124**. The platform **124** is configured to move (e.g., rotate) with respect to the body interface **110** on which the devices **104***a*-**104***n* are disposed. The movement of the platform **124** causes a tool (e.g., the tool **106***a*) to become operatively coupled to (e.g., by aligning with) a device (e.g., the device **104***a*), such that the tool can enhance or change the data characteristics of the device. While FIG. **1** shows that each of the devices **104***a*-**104***n* has a respective one of the tools **106***a*-**106***n* operatively coupled thereto, one of ordinary skill in the art can appreciate that any number of tools can be operatively coupled to any number of devices at any time.

[0101] In some examples, the tool **106***a* (e.g., a first lens) is configured to operatively couple to the device **104***a* (e.g., a camera) when the tools **106***a*-**106***n* (e.g., and the platform **124**) are moved to a first relative position relative to the devices **104***a*-**104***n* (and the body interface **110**). The tool **106***a* being operatively coupled to the device **104***a* enables the device **104***a* to output first data (e.g., a first type of data such as but not limited to, an image with a first resolution). The tool **106***b* (e.g., a second lens) is configured to operatively couple to the device **104***a* when the tools **106***a*-**106***n* (e.g., and the platform **124**) are moved to a second relative position relative to the devices **104***a*-**104***n* (and the body interface **110**). The tool **106***b* being operatively coupled to the device **104***a* enables the one of the devices **104***a* to output second data different from first data. The second data may be a second type of data such as but not limited to, an image with a second resolution.

[0102] FIG. **2**A illustrates a front view of a multi-device **200** according to various arrangements. FIG. **2**B illustrates a perspective view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**C illustrates a side view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**D illustrates a rear view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**E illustrates a side view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**F illustrates a perspective view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**G illustrates a perspective view of the multi-device **200** shown in FIG. **2**A according to various arrangements. FIG. **2**H illustrates a perspective view of the multi-device **200** shown in FIG. **2**A according to various arrangements.

[0103] Referring to FIGS. **1**-**2**H, the multi-device **200** includes a body interface **202** and a plurality of devices **204***a*-**204***d*. The multi-device **200** is an example implementation of the multi-device **102**. The body interface **202** is an example implementation of the body interface **110**. The devices **204***a*-**204***d* are example implementations of the devices **104***a*-**104***n*.

[0104] As shown, the body interface **202** is shaped as a hemisphere. In other examples, the body interface **220** has another suitable shape such as but not limited to, a cube, a cylinder, a torus, an ellipsoid, a disk (e.g., a parabolic disk), and the like. As shown, each of the devices **204***a*-**204***d* are angled outward from a center of the body interface **202**. Each of the devices **204***a*-**204***d* are located at an outer perimeter of the hemispherical body interface **202**. In other examples, the devices **204***a*-**204***d* can be angled inward toward a focal point (e.g., in the example in which the body interface **202** is shaped as a parabolic disk, the devices **204***a*-**204***d* can be angled toward a focal point of the parabolic disk).

[0105] In some arrangements, the body interface **202** is modular such that the body interface **202** can be attached to and detached from another body or instruments (e.g., the body **130**, which can be a robot that provides power, operational instructions, and/or physical positioning to the devices **204***a*-**204***d* with respect to a subject). In some arrangements, the body interface **202** is configured to rotate when attached to a body or an instrument (e.g., the body **130**) such that the devices **204***a*-**204***d* rotate with respect to the attached body, therefore toggling activation among the devices **204***a*-**204***d*. For example, the body interface **202** can be configured to rotate about an axis through the center of the body interface **202**. The axis is perpendicular to a surface of the body interface **202** on which the body is attached in some examples. In the examples in which the body interface **202** has the parabolic disk shape, the axis is through the focal point of the parabolic disk. Further details regarding the instrument and rotation of the devices **204***a*-**204***d* is described herein.

[0106] As described, in some arrangements, each of the devices **204***a*-**204***d* includes a device that is capable of providing healthcare to a subject (e.g., imaging, diagnosis, or treatment of the subject). In one example, one or more of the devices **204***a*, **204***b*, **204***c*, **204***d* include a probe. In one example, one or more of the devices **204***a*-**204***d* include an imaging device configured to determine physiological characteristics of a subject (e.g., blood flow within a particular portion of the subject's body, skeletal composition of the subject, and so on). In one example, examples of each of the devices **204***a*-**204***d* include but are not limited to, a camera, a therapy device (e.g., a laser, a syringe, an ablation device, a light therapy device, an electric shock therapy device, a stitching device (such as a surgical suture), a scalpel, a catheter, an insulin pump, a bandaging device, a respirator, and the like), an ultrasound range device, an ultrasound imaging device, a thermal imaging device, an endoscopy device, an electrography device, a tactile imaging device, a near-infrared imaging device, a near-infrared spectroscopy device, a nuclear medicine device, an optical camera device, a lighting device (e.g., for illumination), a micro-needle drug delivery device, a spectrometer device, a microphone device, an electroencephalography device, a metal detector, and the like.

[0107] In one example, one of the devices **204***a*-**204***d* includes a near-infrared imaging probe that is configured to emit near-infrared light at the skin of a subject, and the near-infrared light that contacts the skin of the subject can distinctly reveal veins of the subject for quick identification by a healthcare provider. In one example, one of the devices **204***a*-**204***d* includes a probe having a concave surface that is configured to be adjacent to or contact a scanning surface (e.g., a head of a subject). The concave surface is configured with a particular pitch to focus generated energy towards the scanning surface (e.g., a Transcranial Doppler (TCD) probe that is configured to be adjacent to or contact and align along a human head, while the TCD probe is configured to provide ultrasound wave emissions directed into the human head).

[0108] Further disclosure regarding probe systems that can be used in conjunction with the multi-device **200** can be found in non-provisional patent application Ser. No. 15/399,648, titled ROBOTIC SYSTEMS FOR CONTROL OF AN ULTRASONIC PROBE, and filed on Jan. 5, 2017, which is incorporated herein by reference in its entirety.

[0109] In one example, one of the devices **204***a*-**204***d* includes a metal detector configured to be used to determine whether the subject has any metal objects (e.g., fillings, braces, or screws) that may interfere with operations of other devices or cause harm to the subject during the scan. In some examples, the metal detector is configured to detect and locate metal objects (e.g., bullets, fragments, or other foreign metal objects) in the subject.

[0110] FIG. **3**A illustrates a perspective view of a multi-device system **300** according to various arrangements. FIG. 3B illustrates a front view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. 3C illustrates a side view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. 3D illustrates a top view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. 3E illustrates a side view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. 3F illustrates an overhead view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. **3**G illustrates a rear view of the multi-device system **300** shown in FIG. **3**A according to various arrangements. FIG. **3**H illustrates a bottom view of the multi-device system **300** shown in FIG. **3**A according to various arrangements.

[0111] In some arrangements, the multi-device system **300** includes the multi-device **200** attached to a body **302**. The body **302** corresponds to the body **130**. In some arrangements, the body **302** includes a robot, robotic manipulator, robotic arm, or the like that automatically operates each of the devices **204***a*-**204***d*, including maneuvering the devices **204***a*-**204***d* at a correct and optimal position along the body of a subject. In that regard, the body **302** includes arm segments **304***a*-**304***c* connected by joints **306***a* and **306***b* as shown. A control circuit (e.g., the controller **132**, the computing platform configured to send the instructions via a network to the body **130**, and the like) is configured to control the movements of the arm segments **304***a*-**304***c* and the joints **306***a* and **306***b* to position the multi-device **200** with respect to the subject (e.g., along, close to, or contacting the body of the subject) in the manner described. In some examples, at least one of the joints **306***a* and **306***b* has six DOFs, such that the body **302** can also be referred to as a redundant manipulator. In other arrangements, at least one of the joints **306***a* and **306***b* has fewer DOFs, such as five (e.g., the Cartesian coordinates (x, y, z), pan, and tilt) or is underactuated such that at least one of the joints **306***a* and **306***b* is controlled in part by a spring. Thus, the body **302** can be employed to move the devices **204***a*-**204***d* to any appropriate location of a subject.

[0112] In some arrangements, the body **302** can be mounted (e.g., via the mounting mechanism **138**) with a portable workstation that includes a monitor (e.g., for providing results of the operations performed on a subject by the multi-device system **300**).

[0113] In addition, the body **302** can automatically select or selectively activate one or more of the devices **204***a*-**204***d* for use. In some arrangements, the multi-device **200** activates one (e.g., the device **204***a*) of the devices **204***a*-**204***d* at a time for use (the active device is shown as device **204***a*), such that the activated device **204***a* is angled towards a subject, while other inactive devices (e.g., the devices **204***b*, **204***c*, and **204***d*) are angled away from the subject. In some arrangements, the activated device **204***a* is aligned with and internally connected to components within the body **302** communicating power, operational instructions, and collected data, while the inactive devices **204***b*, **204***c*, and **204***d* are not connected or aligned as such. In some arrangements, to activate at least one of the inactive devices **204***b*, **204***c*, and **204***d* and to deactivate the active device **204***a*, the body **302** moves (e.g., rotates) the multi-device **200** such that the active device **204***a* is no longer in communication with internal electronics of the body **302**, while another one of the devices **204***b*, **204***c*, and **204***d* is rotatably positioned to be connected such that the newly activated device is capable of operation with respect to a subject. Although four devices **204***a*-**204***d* are shown in the figures, any desired number of different devices can be implemented as part of the multi-device system **300**, such as, but not limited to, one, two, three, or more than four different devices.

[0114] In some arrangements, the multi-device system **300** is capable of atomic force microscopy in conjunction with utilization of the devices **204***a*-**204***d* (or one of the devices **204***a*-**204***d* can include an atomic force microscope). For example, the multi-device **200** (e.g., the device **204***a*) can image a body part of a subject using atomic force microscopy, applying pressure along the body of the subject in incremental distances to generate a 3D contour of the subject. The body **302** can then operate one of the devices **204***a*-**204***d* using the imaged body part. That is, after imaging the body part, the body **302** positions one of the devices **204***a*-**204***d* at an optimal position along the body part using the image of the body part for operation of the one of the devices **204***a*-**204***d*, such as for determining cerebral blood flow velocity in a subject's head using a TCD probe). In some arrangements, the multi-device system **300** can monitor a volume of a body part of a subject over time to determine whether the volume of the body part changes. For example, the multi-device system **300** can detect that a volume of a subject's arm has increased over the span of a few weeks, which can lead to a further diagnosis regarding the cause of the volume increase (e.g., swelling of joints in the arm).

[0115] Accordingly, in some arrangements, the multi-device system **300** includes an automatic system for imaging, diagnosing, and treating a subject. In an example in which a subject is positioned near the multi-device system **300**, the multi-device system **300** can automatically image the subject's body volume, utilize the devices **204***a*-**204***d* with respect to the subject's body based on the image, and provide results of scans made by the devices **204***a*-**204***d* in the manner described. Accordingly, a qualified healthcare provider or technician is not necessary for operating the multi-device system **300**, as the operation can be automated or at least semi-automated.

[0116] As an example, a subject is positioned near the multi-device system **300**. Upon initiation of operation, the multi-device system **300** selects the device **204***a*, which is a camera for providing a coarse three-dimensional image of the subject (e.g., via atomic force microscopy or ultrasound imaging). Once the coarse three-dimensional model of the subject is obtained, the multi-device **300** selects the device **204***b* (e.g., by rotating the device **204***b* into the activation slot such that the device **204***a* becomes deactivated and the device **204***b* becomes activated) that is a high-definition camera for obtaining a fine three-dimensional model of the subject (e.g., via atomic force microscopy or ultrasound imaging). Once the fine three-dimensional image of the subject is obtained, the multi-device system **300** selects another device for performing any desired diagnostic operations on the subject. For example, the multi-device system **300** can select the device **204***c* that is a high-resolution imager that scans the skin of the subject and identifies any abnormal skin conditions that may be pre-cancerous or cancerous (e.g., the device **204***c* can be a high-resolution camera that identifies any discolorations of the skin from the skin's default color tone). As a further example, the multi-device system **300** can select the device **204***d* that is a thermal imaging device and scan the locations of the skin discolorations to confirm via thermal imaging whether those locations are pre-cancerous or cancerous.

[0117] The above example is merely illustrative of the capabilities of the multi-device system **300**, as various sequencing of imaging and diagnostic operations and scans can be utilized to provide healthcare, depending on the scenario and the subject. In some arrangements, the multi-device system **300** is located in hospitals and in physician offices such that it can be implemented as part of a routine physical examination. In some arrangements, the multi-device **300** is located in ambulances as part of emergency healthcare services.

[0118] In other arrangements, the multi-device system **300** is semi-automatic or manual such that a healthcare provider manually selects (e.g., rotates) a device **204***a*, **204***b*, **204***c*, or **204***d* for activation, maneuvers the multi-device system **300** around a subject to appropriately position the device **204***a*, **204***b*, **204***c*, or **204***d*, and manually initiates use of the device **204***a*, **204***b*, **204***c*, or **204***d*.

[0119] FIG. **4**A illustrates a first connection interface **400***a* of a body interface (e.g., the body interface **110** of FIG. **1**) of a multi-device (e.g., the multi-device **102** of FIG. **1**) according to various arrangements. FIG. **4**B illustrates a second connection interface **400***b* of a body (e.g., the body **130** of FIG. **1**) according to various arrangements. Referring to FIGS. **1**-**4**B, contact interfaces **402***a*-**402***d*, **404***a*-**404***d*, **406***a*, **406***b*, **408***a*, and **408***b* are example implementations of the contact interfaces described with reference to FIG. **1**. The first connection interface **400***a* and the second connection interface **400***b* are example implementations of the first connection interface **112** and the second connection interface **140**, respectively.

[0120] The second connection interface **400***b* includes at least a contact interface **406***a* that is operatively connected to the power supply **134** and is configured to provide power to one of the devices (e.g., the devices **204***a*-**204***d*) disposed on the body interface on which the first connection interface **400***a* is positioned. The second connection interface **400***b* further includes at least a contact interface **408***a* that is operatively connected to the controller **132** and is configured to provide operational instructions to one of the devices (e.g., the devices **204***a*-**204***d*) disposed on the body interface and receive data collected by the one of the devices. Therefore, the contact interfaces **406***a* and **408***a* are two separate contact interfaces spaced apart from one another with a gap. The combination of the contact interfaces **406***a* and **408***a* provides power and data/operational instructions communication capabilities, to activate one of the devices. In that regard, the contact interfaces **406***a* and **408***a* correspond to an activation slot to activate one of the devices. The second connection interface **400***b* may also have one or more additional activation slots (e.g., an additional activation slot for the contact interfaces **406***b* and **408***b*) configured to provide power and data/operational instructions communication capabilities to activate one or more additional devices, to enable simultaneous operation of two or more devices. The contact interfaces **406***b* and **408***b* are contact interfaces such as but not limited to, the contact interfaces **406***a* and **408***a*. While a given activation slot is shown to include two separate contact interfaces **406***a* and **406***a* for power and data/operational instructions, separately, in alternative arrangements, a given activation slot may have a single contact interface configured to provide power and data/operational instructions, for example, through modulated power signals as described herein.

[0121] The first connection interface **400***a* includes at least a contact interface **402***a* that is operatively connected to a first device (e.g., the device **204***a*) and is configured to provide power to the first device disposed on the body interface on which the first connection interface **400***a* is located. The first connection interface **400***a* further includes at least a contact interface **404***a* that is operatively connected to a controller (e.g., a microprocessor or another suitable processing unit) for the first device (e.g., the device **204***a*) and is configured to communicate data/operational instructions to and from the first device. Therefore, the contact interfaces **402***a* and **404***a* are two separate contact interfaces spaced apart from one another with a gap. The combination of the contact interfaces **402***a* and **404***a* provide power and data/operational instructions communication capabilities when the contact interfaces **402***a* and **404***a* align with and contact the contact interfaces **406***a* and **408***a* (or the contact interfaces **406***b* and **408***b*), respectively, to activate the first device.

[0122] Similarly, the combination of the contact interfaces **402***b* and **404***b* provide power and data/operational instructions communication capabilities when the contact interfaces **402***b* and **404***b* align with and contact the contact interfaces **406***a* and **408***a* (or the contact interfaces **406***b* and **408***b*), respectively, to activate a second device (e.g., the device **204***b*). The combination of the contact interfaces **402***c* and **404***c* provide power and data/operational instructions communication capabilities when the contact interfaces **402***c* and **404***c* align with and contact the contact interfaces **406***a* and **408***a* (or the contact interfaces **406***b* and **408***b*), respectively, to activate a third device (e.g., the device **204***c*). The combination of the contact interfaces **402***d* and **404***d* provide power and data/operational instructions communication capabilities when the contact interfaces **402***d* and **404***d* align with and contact the contact interfaces **406***a* and **408***a* (or the contact interfaces **406***b* and **408***b*), respectively, to activate a fourth device (e.g., the device **204***d*).

[0123] One or more of the first connection interface **400***a* and the second connection interface **400***b* can be configured to be rotated with respect to one another, to align the contact interfaces (e.g., the contact interfaces **402***a* and **404***a*) with contact interfaces **406***a* and **408***a*, to activate a device (e.g., the first device). As described, a movement mechanism (e.g., the movement mechanism **120**) on one or both of the body interface (e.g., the body interface **110**) and an end of the body **130** is configured to rotate the first connection interface **400***a* and/or the second connection interface **400***b* about centers **410***a* and **410***b*. Assembling the first connection interface **400***a* and the second connection interface **400***b* includes rotatably supporting the first connection interface **400***a* and the second connection interface **400***b* such that the centers **410***a* and **420***a* are aligned. As shown, the first connection interface **400***a* and the second connection interface **400***b* have a same shape (e.g., a circular surface). The contact interfaces **402***a*-**402***d*, **404***a*-**404***d*, **406***a*, **406***b*, **408***a*, and **408***b* can be rotated about an axis through the centers **410***a* and **410***b*. The axis can be perpendicular to the surfaces of the first connection interface **400***a* and the second connection interface **400***b*.

[0124] In particular, the contact interface **406***a* (and the contact interface **406***b*, if provided) is on a circular path defined by the contact interfaces **402***a*-**402***d*, such that one of the contact interfaces **402***a*-**402***d* can be aligned with the contact interface **406***a* (or the contact interface **406***b*, if provided). The contact interface **408***a* (and the contact interface **408***b*, if provided) is on a circular path defined by the contact interfaces **404***a*-**404***d*, such that one of the contact interfaces **404***a*-**404***d* can be aligned with the contact interface **408***a* (or the contact interface **408***b*, if provided). Although the contact interfaces **402***a*-**402***d* and **404***a*-**404***d* are spaced apart along respective circular paths, one of ordinary skill in the art can appreciate that other arrangements of the contact interfaces **402***a*-**402***d* and **404***a*-**404***d* can be suitably implemented.

[0125] If the contact interfaces **406***b* and **408***b* are provided, the relative positions of the contact interfaces **406***a*, **406***b*, **408***a*, and **408***b* correspond to the relative positions of two sets of the contact interfaces (e.g., the contact interfaces **402***a*, **402***d*, **404***a*, **404***d*) on the first connection interface **400***a*. This enables two sets of the contact interfaces to align and contact the contact interfaces **406***a*, **406***b*, **408***a*, and **408***b* simultaneously, for simultaneous activation and operation.

[0126] Responsive to the first connection interface **400***a* being in a first predetermined (relative) position relative to the second connection interface **400***b*, the contact interfaces **402***a* and **404***a* are aligned with and contact the contact interfaces **406***a* and **408***a*, respectively, to activate the first device. If the contact interfaces **406***b* and **408***b* are provided, in the first predetermined position, the contact interfaces **402***d* and **404***d* are aligned with and contact the contact interfaces **406***b* and **408***b*, respectively, to activate the fourth device. Responsive to the first connection interface **400***a* being in a second predetermined (relative) position relative to the second connection interface **400***b*, the contact interfaces **402***b* and **404***b* are aligned with and contact the contact interfaces **406***a* and **408***a*, respectively, to activate the second device. Responsive to the first connection interface **400***a* being in a third predetermined (relative) position relative to the second connection interface **400***b*, the contact interfaces **402***c* and **404***c* are aligned with and contact the contact interfaces **406***a* and **408***a*, respectively, to activate the third device. Responsive to the first connection interface **400***a* being in a fourth predetermined (relative) position relative to the second connection interface **400***b*, the contact interfaces **402***d* and **404***d* are aligned with and contact the contact interfaces **406***a* and **408***a*, respectively, to activate the fourth device.

[0127] FIG. **5**A illustrates a first connection interface **500***a* of a body interface (e.g., the body interface **110** of FIG. **1**) of a multi-device (e.g., the multi-device **102** of FIG. **1**) according to various arrangements. FIG. **5**A illustrates a second connection interface **500***b* of a body (e.g., the body **130** of FIG. **1**) according to various arrangements.

[0128] Referring to FIGS. **1**-**5**B, the second connection interface **500***b* includes at least a contact interface **506** that is operatively connected to the power supply **134** and is configured to provide power to the devices (e.g., the devices **204***a*-**204***d*) disposed on the body interface on which the first connection interface **500***a* is positioned. The second connection interface **500***b* further includes at least a contact interface **508** that is operatively connected to the controller **132** and is configured to provide operational instructions to one of the devices (e.g., the devices **204***a*-**204***d*) disposed on the body interface. The combination of the contact interfaces **506** and **508** provide power and operational instructions communication capabilities, to activate one of the devices.

[0129] The first connection interface **500***a* includes at least a contact interface **502** that is operatively connected to devices (e.g., the devices **204***a*-**204***d*) and is configured to provide power to all the devices disposed on the body interface on which the first connection interface **500***a* is located. Thus, all of the devices can be simultaneously powered. Regardless of the manner in which the first connection interface **500***a* and the second connection interface **500***b* rotate, the contact interface **502** and the contact interface **506** are always aligned and in contact, given that the centers of the contact interface **502** and the contact interface **506** align with the centers of the first connection interface **500***a* and the second connection interface **500***b*. Thus, the devices can always be powered.

[0130] The first connection interface **500***a* further includes contact interfaces **504***a*-**504***d* operatively connected to a controller (e.g., a microprocessor or another suitable processing unit) and are configured to communicate operational instructions to a respective device. The first connection interface **500***a* and the second connection interface **500***b* are configured to rotate relative to one another in the manner described with respect to the first connection interface **400***a* and the second connection interface **400***b*. The devices can be selectively activated according to the rotation of the first connection interface **500***a* and the second connection interface **500***b* (e.g., the alignment and contact of the contact interface **508** with one of the contact interfaces **504***a*-**504***d*) in the manner described with respect to the contact interfaces **406***a* and **402***a*-**402***d*.

[0131] The first connection interface **500***a* further includes a component **505***a*, **505***b*, **505***c*, or **505***d* for each of the devices configured to fire collected data onto a data transmission ring (e.g., a fiber optics ring **510**) on the second connection interface **500***b*. The fiber optics ring **510** is operatively coupled to the controller and can relay the collected data to the controller **132**. This enables one or more activated ones of the devices to send data to the controller **510** regardless of the relative position of the first connection interface **500***a* and the second connection interface **500***b*. This further enables multiple activated devices to send data to the fiber optics ring **510** simultaneously. For example, two or more devices are activated simultaneously (e.g., not selectively activated). Thus, the two or more devices can simultaneously fire collected data to the fiber optics ring **510** to be relayed to the controller **132**.

[0132] FIG. **6** illustrates tools **606***a*-**606***d* being operatively coupled to devices **604***a*-**604***d* according to various arrangements. Referring to FIG. **106**, the tools **606***a*-**606***d* are example implementations of the tools **106***a*-**106***n*. The devices **604***a*-**604***d* are example implementations of the devices **104***a*-**104***n*. The tools **606***a*-**606***d* are shown to be disposed on a platform **624**, which is an example implementation of the platform **124**. The devices **604***a*-**604***d* are shown to be disposed on a body interface **610**, which is an example implementation of the body interface **110**. The platform **624** may be detachably mounted to the body interface **610** via magnets, spring-loaded pins, clamps, locks, latches, bolts, buckles, clips, hook-and-look fasteners, pegs, pins, rivets, snap fasteners, straps, and another suitable mechanical fastener. The tools **606***a*-**606***d* are no longer needed when the operations of the device having data characteristics that can be modified by the tools **606***a*-**606***d* are completed. The platform **624** can be automatically or manually detached from the body interface **610**, to allow other devices to be activated and/or to operate.

[0133] A movement mechanism (e.g., a motor assembly) on the body interface **610** is configured to rotate the body interface **610** and/or the platform **624** about centers **605** and **625**. Assembling the body interface **610** and the platform **624** includes rotatably supporting the body interface **610** and the platform **624** such that the centers **605** and **625** are aligned. As shown, the body interface **610** and the platform **624** have a same shape (e.g., a circular surface). The tools **606***a*-**606***d* and the devices **604***a*-**604***d* can be rotated about an axis through the centers **605** and **625**. The axis can be perpendicular to the surfaces of the body interface **610** and the platform **624**. In some arrangements, a center (e.g., the center **410***b*) of the second connection interface (e.g., the second connection interface **400***b*) is also on the axis, such that the body interface **610**, the platform **624**, and the second connection interface are configured to rotate about a same axis.

[0134] Examples of the devices **604***a*-**604***d* include but are not limited to, a photo-sensor, an infrared sensor, a particle detector, a laser emitter, and the like. Examples of the tools **606***a*-**606***d* include but are not limited to, a lens, a photo-projector, a filter configured to filter or pass designated light or laser frequencies, an amplifier that amplifies a signal, an attenuator that attenuates a signal, and a waveguide.

[0135] In some arrangements, the device **604***a* is a photo-sensor (e.g., a complementary metal-oxide-semiconductor (CMOS)), and the tool **606***a* is a wide-angle lens. The tool **606***a* is operatively coupled to the device **604***a* when the tools **606***a*-**606***d* (and the platform **624**) are in a first position relative to the devices **604***a*-**604***d* (and the body interface **110**), causing the tool **606***a* to align with the device **604***a*. The first data generated by the device **604***a* (as modified by the tool **606***a*) is first image data capturing a first portion of a subject. Given that the tool **606***a* is a wide-angle lens, the device **604***a* can capture a larger portion of the subject. The tool **606***b* is a zoom lens. The tool **606***b* is operatively coupled to the device **604***a* when the tools **606***a*-**606***d* (and the platform **624**) are in a second position relative to the devices **604***a*-**604***d* (and the body interface **110**), causing the tool **606***b* to align with the device **604***a*. The second data generated by the device **604***a* (as modified by the tool **606***b*) is second image data capturing a second portion of a subject. Given that the tool **606***a* is a zoom lens, the device **604***a* can capture a smaller portion of the subject, with improved resolution. In that regard, the tool **606***a* can be used in connection with the device **604***a* to perform a full-body imaging or 3D imaging of the subject, the second tool **606***b* can be used in connection with the device **604***a* to perform localized or target imaging for a particular area of the body of the subject.

[0136] In some arrangements, the device **604***c* is a laser emitter, and the tool **606***c* and the tool **606***d* are grid lenses or waveguides configured to modify laser characteristics such that a laser grid can be projected, for example onto the subject by the device **604***c*. The tool **606***c* is operatively coupled to the device **604***c* when the tools **606***a*-**606***d* (and the platform **624**) are in the first position relative to the devices **604***a*-**604***d* (and the body interface **110**), causing the tool **606***c* to align with the device **604***c*. The devices **604***a* and **604***c* can be simultaneously activated such that in the first position, the wide-angle images collected by the devices **604***a* (as modified by the tool **606***a*) capture the subject with the laser grid projected thereon, for example, to assist any automatic registration of the subject or another one of the devices **604***a*-**604***d*. Automatic registration refers to defining a workspace of the devices **604***a*-**604***n* and the tools **606***a*-**606***n* by defining boundaries on the body of the subject within which the devices **604***a*-**604***n* and the tools **606***a*-**606***n* operate. For example, imaging devices can capture images or videos of the subject, including anatomical landmarks or features of the subject. The tool **606***d* is operatively coupled to the device **604***c* when the tools **606***a*-**606***d* (and the platform **624**) are in the second position relative to the devices **604***a*-**604***d* (and the body interface **110**), causing the tool **606***d* to align with the device **604***c*. The devices **604***a* and **604***c* can be simultaneously activated such that in the second position, the zoom images collected by the devices **604***a* (as modified by the tool **606***b*) capture the portion of the subject with the laser grid projected thereon. The laser grid can be used as reference lines to segment the body of the subject or a portion thereof to assist operations or registration of the devices **604***a*-**604***n* and the tools **606***a*-**606***n*, for example, by defining paths or spaces on the body, determining 3D characteristics across the body to image depths of the body, and the like.

[0137] In another example involving simultaneous operation of the devices and tools, the device **604***c* is a light emitter (e.g., a black light emitter, a non-visible light emitter configured to facilitate identification or portions or feature of the body, including veins, such that other devices such as a syringe can be operated based on images captured under the light emitter), and the tool **606***c* is a black light lens configured to modify (e.g., focus) the black light emitted by the device **604***c*. The tool **606***c* is operatively coupled to the device **604***c* when the tools **606***a*-**606***d* (and the platform **624**) are in the first position relative to the devices **604***a*-**604***d* (and the body interface **110**), causing the tool **606***c* to align with the device **604***c*. The devices **604***a* and **604***c* can be simultaneously activated such that in the first position, the wide-angle images collected by the devices **604***a* (as modified by the tool **606***a*) capture the subject under black light.

[0138] FIG. **7** is a flow diagram illustrating a method **700** for using the multi-device system **100** according to various arrangements. Referring to FIGS. **1-7**, the device **104***a* (e.g., an ultrasound image device or another suitable image device) determines imaging data for a portion of a subject by scanning the portion of the subject, at **710**. For example, the device **104***a* collects ultrasound data of a heart valve of the subject. At **720**, the controller **132** determines an image projection corresponding to the imaging data by processing the imaging data. Processing includes at least generating an image of the heart valve of the subject based on the ultrasound data in some examples. At **730**, the device **104***b* (e.g., a projector) is configured to project the image projection unto the subject. The image projection allows a healthcare provider to visualize the portion of the subject's body that has been imaged, for example, using ultrasound. Images are updated in real-time such that, for example, the healthcare provider can visualize real-time physical changes (e.g., a beating heart, changes due to surgery, and the like). For example, the healthcare provider can perceive images or videos of bone or vasculature in real-time, or other organ/tissue. The image projection is projected unto the same portion (e.g., unto a skin of the subject that is proximate to the heart valve) of the subject or unto a different portion of the subject, to facilitate healthcare. In some arrangements, the method **700** further includes performing registration with respect to the portion (e.g., the heart) of the subject using the device **104***c*. Registration refers to determining a position corresponding to the portion of interest of the subject by a camera or photo-sensor such that the device **104***a* can be configured to generate the imaging data at the position.

[0139] FIG. **8** is a flow diagram illustrating a method **800** for using the multi-device system **100** according to various arrangements. Referring to FIGS. **1-8**, the controller **132** determines that a semi-automatic movement feature is enabled, at **810**. For example, the controller **132** can determine that the semi-automatic movement feature is enabled responsive to determining that the semi-automatic switch **148** is in the first state.

[0140] At **820**, in response to determining that the semi-automatic movement feature is enabled, the multi-device **102** is allowed to be moved by a user (e.g., a healthcare provider) to a first position relative to the subject. For example, responsive to determining that the semi-automatic movement feature is enabled, the controller **132** is configured to loosen one or more joints (e.g., the joints **306***a* and **306***b*) on the body **130** (**302**), such that the user can move the multi-device **102** (**200**) by moving the manual interface **150**. The user can bring the multi-device **102** closer to the first portion by moving the manual interface **150**. Such arrangements conserve time needed to execute a full-body registration to identify the first portion and to automatically move the multi-device **102** close to the first portion. For example, in a procedure involving echocardiogram, the user can enable the semi-automatic movement feature and push the multi-device **102** (via the manual interface **150**) toward a chest of the subject.

[0141] At **830**, the multi-device **102** (e.g., the device **104***a*, which may be a camera or a photo-sensor) performs a first registration with respect to a first portion of a body of the subject in the first position. The controller **132** automatically adjusts the first position after the multi-device **102** has been moved closer to the first portion by the user, to position the multi-device **102** in the optimal data acquisition position for subject imaging or diagnosis. In other words, the registration process more finely defines or identifies the first portion on which the subject diagnosis is to be performed. The first registration process refines the first position.

[0142] At **840**, the multi-device **102** (e.g., the device **104***b*) performs first subject diagnosis with respect to the first portion of the body of the subject based on the first registration. The first subject diagnosis includes any suitable procedure described herein.

[0143] In some arrangements, the method **800** further includes allowing the multi-device **102** to be moved by the user to a second position relative to the subject, after the first subject imaging or diagnosis is performed. From the first position, the user can bring the multi-device **102** closer to a second portion by moving the manual interface **150**. The multi-device **102** (e.g., the device **104***a*) performs a second registration with respect to the second portion of the body of the subject in the second position, in the manner described similar to the first registration process. The second subject imaging or diagnosis with respect to the second portion of the body of the subject can be performed based on the second registration, in the manner described similar to the first subject diagnosis.

[0144] In some arrangements, the first portion is larger in size than the second portion. In some examples, the processes (e.g., **830-840**) with respect to the first portion are full body registration and diagnosis processes. The full body registration and diagnosis processes may identify potential concerns in, for example, the second portion, which may be a part of the first portion. In that regard, the second registration is performed based on a smaller workspace as compared to that of the first registration. In some example, the first registration identifies an area of the body of the subject to be focused on, and the second registration corresponds to the area identified by the first registration.

[0145] In some arrangements, the first portion and the second portion correspond to different body parts of the subject. This allows the multi-device system **100** to perform automatic registration and imaging or diagnosis processes for different body parts (e.g., organs).

[0146] FIG. **9** illustrates a multi-device system **900** according to various arrangements. The multi-device system **900** is an example implementation of the multi-device system **100**. Referring to FIGS. **1-9**, the multi-device system **900** includes a multi-device **902**, a body **930**, a manual interface **950**, and a mounting mechanism **938**, each of which corresponds to a respective one of the multi-device **102**, the body **130**, the manual interface **150**, the mounting mechanism **138**. In particular, the multi-device **902** is arranged on an end of the body **930**, which is a robotic manipulator having arms and joints. The manual interface **950** is a handle arranged on an arm segment of the body **930** closest to the multi-device **902**. The mounting mechanism **938** is a clamp configured to mount the multi-device system **900** to a movable desk. The multi-device system **900** includes a power supply **934** or a power cord **935**. The power supply **934** and the power cord **935** are example implementations of the power supply **134**. The power supply **934** is a battery arranged on the body **930**, such that an external power source is not needed. The power supply **934** is rechargeable and/or replaceable. The power cord **935** can receive power from an external power source (e.g., an electrical outlet). The body **130** includes a network device (not shown) corresponding to the network device **136** and is configured to receive operational instructions from a computing platform **980** and/or send data to the computing platform **980**.

[0147] FIG. **10** illustrates a multi-device system **1000** according to various arrangements. The multi-device system **1000** is an example implementation of the multi-device system **100**. Referring to FIGS. **1-10**, the multi-device system **1000** includes a multi-device **1002** and a body **1030**, each of which corresponds to a respective one of the multi-device **102** and the body **130**. In particular, the multi-device **1002** is arranged on an end of the body **1030**, which is a robotic manipulator having arms and joints. The body **1030** is attached to a movable cart **1090** having an internal storage area. The internal storage area is configured to store at least one replacement body **1030'**, a power supply **1034** (corresponding to the power supply **134**), and replacement devices **1004'**. Each of the at least one replacement body **1030'** can have different arm lengths, number of joints, functions, and the like, and can be implemented in accordance with the desired use. In one example, the replacement body **1030'** may have more joints for finer movements within the workspace. The replacement multi-devices **1002'** can have different devices or a combination of devices as compared to the devices of the multi-device **1002**. For example, one of the replacement multi-devices **1002'** can have diagnostic devices arranged thereon, and another one of the replacement multi-devices **1002'** can have therapeutic devices arranged thereon, where the replacement multi-devices **1002'** can be swapped based on implementation and desired use.

[0148] The cart **1090** has an upper surface configured to hold replacement multi-devices **1002'**. A user can replace the multi-device **1002** with one of the replacement multi-devices **1002'** manually, replace the devices on the multi-device **1002** with the replacement devices **1004'**, and replace the body **1030** with the replacement body **1030'** manually. In other examples, the body **1030** can move the multi-device **1002** over the upper surface of the cart **1090**, automatically detach or otherwise release the multi-device **1002**, and attach the replacement multi-device **1002**. Similarly, the body **1030** can move the multi-device **1002** into the internal storage area of the cart **1090**, automatically detach or otherwise release one or more devices on the multi-device **1002**, and attach to the replacement devices **1004'**. In other examples, the replacement multi-devices **1002'** can be stored in the internal storage area and replaced in a manner similar to described with respect to the replacement devices **1004'**. The replacement devices **1004'** can be disposed on the upper surface and replaced in a manner similar to described with respect to the replacement multi-devices **1002'**. The tools **106*a*-106*n*** can be stored and replaced in a similar manner.

[0149] While the arrangements herein show one multi-device operatively coupled to a body, multiple multi-devices can be arranged on a same body. For example, one body may include multiple branch arms, an end of each branch arm is operatively coupled to a multi-device in the manner described. In addition, multiple bodies each having at least one multi-device provided thereon can be similarly implemented. The multi-devices can be simultaneously activated to perform a joint task. For example, a device (e.g., an ultrasound device) on each of multiple multi-devices can be pointed to a kidney stone or blood clot on the subject to focus energy to jointly break down the kidney stone or blood clot. In another example, a first device (e.g., a lighting device) of a first multi-device illuminates at least a portion of the subject while a second device (e.g., a laser emitter modified by a waveguide tool) of a second multi-device projects a laser grid onto the at least a portion of the subject, while a third device (e.g., a photo-sensor) of a third multi-device generates images of the at least one portion of the subject.

[0150] The above used terms, including "held fast," "mount," "attached," "coupled," "affixed," "connected," "secured," and the like are used interchangeably. In addition, while certain arrangements have been described to include a first element as being "coupled" (or "attached," "connected," "fastened," etc.) to a second element, the first element may be directly coupled to the second element or may be indirectly coupled to the second element via a third element.

[0151] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but are to be accorded the full scope consistent with the language, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more. All structural and functional equivalents to the elements of the various aspects described throughout the previous description that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase "means for."

[0152] It is understood that the specific order or hierarchy of steps in the processes disclosed is an example of illustrative approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged while remaining within the scope of the previous description. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0153] The previous description of the disclosed implementations is provided to enable any person skilled in the art to make or use the disclosed subject matter. Various modifications to these implementations will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other implementations without departing from the spirit or scope of the previous description. Thus, the previous description is not intended to be limited to the implementations shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A multi-device system for providing healthcare to a subject, comprising:

a multi-device comprising:
a body interface;
a plurality of devices fixed to the body interface, each of the plurality of devices configured to collect data of or provide therapy to the subject; and
a body operatively coupled to the multi-device at the body interface, wherein the body is configured to position the multi-device with respect to the subject, and the body interface is configured to move relative to the body to selectively activate at least one of the plurality of devices.

2. The multi-device system of claim **1**, wherein each of the plurality of devices is configured to collect data of the subject and comprises at least one of a camera, an ultrasound range device, an ultrasound imaging device, a thermal imaging device, a near-infrared imaging device, a near-infrared spectroscopy device, an optical camera device, a lighting device, a spectrometer device, a microphone device, an electroencephalography device, and a metal detector.

3. The multi-device system of claim **1**, wherein each of the plurality of devices is configured to provide therapy to the subject and comprises at least one of a laser, a syringe, an ablation device, a light therapy device, an electric shock therapy device, a stitching device, a scalpel, a catheter, an insulin pump, a bandaging device, and a respirator.

4. The multi-device system of claim **1**, further comprising:
a power supply configured to provide power to the plurality of devices; and
a controller configured to transmit operational instructions to the plurality of devices and receive the data collected by the plurality of devices,
wherein the at least one of the plurality of devices is activated when the at least one of the plurality of devices is receiving the power and the operational instructions.

5. The multi-device system of claim **4**, wherein
the body interface comprises a first connection interface operatively coupled to each of the plurality of devices;
the body comprises a second connection interface operatively coupled to the power supply and the controller;
the second connection interface is configured to provide the power and the operational instructions to the first connection interface for the activated at least one of the plurality of devices by operatively coupling to the first connection interface when the body interface is moved relative to the body to a predetermined position; and
the first connection interface is configured to provide the data collected by the at least one of the plurality of devices to the second connection interface by operatively coupling to the second connection interface.

6. The multi-device system of claim **5**, wherein
the first connection interface for the at least one of the plurality of devices comprises a first power interface and a first data communication interface separate from the first power interface;
the second connection interface comprises a second power interface and a second data communication interface separate from the second power interface;
the second power interface is configured to operatively couple to the first power interface when the body interface is moved relative to the body to the predetermined position to provide the power to the first power interface; and
the second data communication interface is configured to operatively couple to the first data communication interface when the body interface is moved relative to the body to the predetermined position to provide the operational instructions to the first data communication interface and to receive the data collected by the activated at least one of the plurality of devices from the first data communication interface.

7. The multi-device system of claim **5**, wherein the second connection interface is configured to provide the power and the operational instructions to the first connection interface by providing to the first connection interface modulated power signals comprising the power from the power supply and the operational instructions from the controller.

8. The multi-device system of claim **5**, wherein the body interface comprises a locking device configured to structurally maintain the predetermine position.

9. The multi-device system of claim **4**, wherein
the body interface comprises a first connection interface operatively coupled to each of the plurality of devices;
the body comprises a second connection interface operatively coupled to the power supply and the controller;
the second connection interface comprises at least one data transmission ring configured to receive the data collected by the at least one of the plurality of devices.

10. The multi-device system of claim **1**, wherein the body interface being configured to move relative to the body to selectively activate at least one of the plurality of devices by:
responsive to the body interface being moved relative to the body to a first predetermined position, a first device of the plurality of devices is activated while a second device of the plurality of devices is inactivated; and
responsive to the body interface being moved relative to the body to a second predetermined position, the second device is activated while the first device is inactivated.

11. The multi-device system of claim **1**, wherein the body interface is configured to rotate relative to the body to selectively activate the at least one of the plurality of devices.

12. The multi-device system of claim **1**, wherein the at least one of the plurality of devices comprises a force controller configured to determine a force exerted by the at least one of the plurality of devices against the subject.

13. The multi-device system of claim **1**, wherein
the multi-device further comprises a plurality of tools;
the plurality of tools is configured to move relative to the plurality of devices;
a first tool of the plurality of tools is configured to operatively couple to one of the at least one of the plurality of devices when the plurality of tools is moved to a first relative position relative to the plurality of devices;
the first tool being operatively coupled to the one of the at least one of the plurality of devices enables the one of the at least one of the plurality of devices to output first data;
a second tool of the plurality of tools is configured to operatively couple to the one of the at least one of the plurality of devices when the plurality of tools is moved to a second relative position relative to the plurality of devices; and
the second tool being operatively coupled to the one of the at least one of the plurality of devices enables the one

of the at least one of the plurality of devices to output second data different from first data.

14. The multi-device system of claim **13**, wherein

the one of the plurality of devices is one of a photo-sensor, an infrared sensor, a particle detector, and a laser emitter; and

each of the plurality of tools is at least one of a lens, a photo-projector, and a waveguide.

15. The multi-device system of claim **13**, wherein

the one of the plurality of devices is a photo-sensor;

the first tool is a wide-angle lens;

the first data comprise first image data capturing a first portion of the subject;

the second tool is a zoom lens;

the second data comprise second image data capturing a second portion of the subject; and

the first portion is larger than the second portion.

16. The multi-device system of claim **15**, wherein

another one of the plurality of devices is a laser emitter;

the plurality of tools comprises a grid lens configured to be operatively coupled to the laser emitter in the first relative position; and

the laser emitter is configured to project a grid onto the subject while the first data is being collected by the photo-sensor through the wide-angle lens or while the second data is being collected by the photo-sensor through the zoom lens.

17. The multi-device system of claim **1**, wherein

the body comprises a robotic manipulator having at least two arm segments and a joint; and

the robotic manipulator is configured to position the multi-device with respect to the subject.

18. The multi-device system of claim **1**, wherein the body further comprises at least one of:

a mounting mechanism configured to detachably mount the multi-device system to an object;

a battery; and

a network device.

19. The multi-device system of claim **1**, wherein the body further comprises a manual interface configured to allow the multi-device to be moved relative to the subject by a user of the multi-device system.

20. The multi-device system of claim **19**, wherein

the body further comprises a semi-automatic switch;

the semi-automatic switch being in a first state corresponds to allowing the multi-device to be moved relative to the subject by the user via the manual interface; and

the semi-automatic switch being in a second state corresponds to disallowing the multi-device to be moved relative to the subject by the user.

21. A method for providing healthcare to a subject using a multi-device system, the method comprising:

providing a multi-device comprising:

a body interface;

a plurality of devices fixed to the body interface, wherein each of the plurality of devices is configured to provide healthcare to the subject by collecting data; and

providing a body operatively coupled to the multi-device at the body interface, wherein the body is configured to position the multi-device with respect to the subject, and the body interface is configured to move relative to the body to selectively activate at least one of the plurality of devices.

22. The method of claim **21**, further comprising:

providing a plurality of tools, wherein

the plurality of tools is configured to move relative to the plurality of devices;

a first tool of the plurality of tools is configured to operatively couple to a first device of the at least one of the plurality of devices when the plurality of tools is moved to a first relative position relative to the plurality of devices;

the first tool being operatively coupled to the first device enables the first device to output first data;

a second tool of the plurality of tools is configured to operatively couple to the first device when the plurality of tools is moved to a second relative position relative to the plurality of devices; and

the second tool being operatively coupled to the first device enables the first device to output second data different from first data.

23. The method of claim **21**, wherein the first device and a second device of the at least one of the plurality of devices are configured to be activated simultaneously.

24. The method of claim **23**, wherein a third tool of the plurality of tools is configured to operatively couple to the second device when the plurality of tools is moved to the first relative position relative to the plurality of devices.

25. The method of claim **24**, wherein

the first device is a photo-sensor;

the first tool is a wide-angle lens;

the second device is a laser emitter; and

the second tool is a grid lens.

26. A method for providing healthcare to a subject using multi-device system having a multi-device and a body configured to move the multi-device relative to the subject, the method comprising:

determining that a semi-automatic movement feature is enabled;

in response to determining that the semi-automatic movement feature is enabled, allowing the multi-device to be moved by a user to a first position relative to the subject;

performing first registration with respect to a first portion of a body of the subject in the first position; and

performing first subject imaging with respect to the first portion of the body of the subject based on the first registration.

27. The method of claim **26**, wherein allowing the multi-device to be moved relative to the subject by the user comprises:

providing a manual interface on the body or the multi-device, wherein the manual interface is configured to interact with the user to allow the user to move the multi-device; and

enabling the user to move the multi-device by loosening one or more joints on the body.

28. The method of claim **26**, further comprising:

allowing the multi-device to be moved by the user to a second position relative to the subject;

performing second registration with respect to a second portion of a body of the subject in the second position; and performing second subject imaging with respect to the second portion of the body of the subject based on the second registration.

29. A method for providing healthcare to a subject using a multi-device system having a controller, a multi-device, and a body configured to move the multi-device relative to the subject, the multi-device having a first device and a second device, the method comprising:

determining imaging data for a portion of the subject by scanning, using the first device, the portion of the subject;

determining image projection corresponding to the imaging data by processing the imaging data using the controller; and

projecting, using the second device, the image projection unto the subject.

30. The method of claim **31**, wherein the image projection is projected using the second device unto the portion of the subject or a different portion of the subject.

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专利名称(译)	多设备系统		
公开(公告)号	US20190051409A1	公开(公告)日	2019-02-14
申请号	US16/101332	申请日	2018-08-10
[标]申请(专利权)人(译)	神经ANALYTICS		
申请(专利权)人(译)	神经分析公司		
当前申请(专利权)人(译)	神经分析公司		
[标]发明人	PETROSSIAN LEO ZWIERSTRA JAN CASTRO RICHARD STITH LANE		
发明人	PETROSSIAN, LEO ZWIERSTRA, JAN CASTRO, RICHARD STITH, LANE		
IPC分类号	G16H40/60 A61B5/00 G06F3/01		
CPC分类号	G16H40/60 A61B5/0024 G06F3/011 A61B5/0035 A61B5/0036 A61B1/00149 A61B34/30 A61B2017/00477 A61B2090/061 A61B2090/065 G16H20/00 G16H40/63		
优先权	62/544362 2017-08-11 US		
外部链接	Espacenet USPTO		

摘要(译)

本文描述的布置涉及被配置为向受试者提供医疗保健的多设备系统。该多设备系统包括多设备，该多设备具有主体接口，固定到主体接口的多个设备，被配置为收集对象的数据的多个设备中的每一个，以及可操作地耦合到多设备的主体。身体界面。主体被配置为相对于对象定位多设备。主体接口被配置为相对于主体移动以选择性地激活多个设备中的至少一个。