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Sterile interface module for robotic surgical assemblies

Abstract

A robotic surgical assembly includes an instrument drive unit and a sterile interface module for coupling an electromechanical robotic surgical instrument to the instrument drive unit. The sterile interface module is detachable from the instrument drive unit and is equipped with a mechanism that allows for a manual actuation of the surgical instrument.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
9033958	12/2014	Mailloux	606/1	A61B 34/30
9271705	12/2015	Vaughn	N/A	B23B 31/22
11890070	12/2023	Lambrecht	N/A	A61B 34/30
2013/0245647	12/2012	Martin et al.	N/A	N/A
2016/0081754	12/2015	Kostrzewski et al.	N/A	N/A
2016/0151115	12/2015	Karguth	606/41	A61B 1/00149
2017/0135773	12/2016	Lohmeier et al.	N/A	N/A
2018/0126546	12/2017	Vaders	N/A	B25J 9/0009
2018/0168752	12/2017	Scheib et al.	N/A	N/A
2019/0021801	12/2018	Radgowski	N/A	A61B 34/30
2019/0254763	12/2018	Lambrecht	N/A	A61B 34/30
2020/0060516	12/2019	Baez, Jr.	N/A	A61B 1/0053
2020/0222130	12/2019	Cooper	N/A	A61B 34/70
2021/0093403	12/2020	Betsugi	N/A	A61B 34/30

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
105163685	12/2014	CN	N/A
107666877	12/2017	CN	N/A
109219414	12/2018	CN	N/A
3616641	12/2019	EP	N/A
2017205308	12/2016	WO	N/A
2017205329	12/2016	WO	N/A

OTHER PUBLICATIONS

European Search Report Dated Jul. 26, 2023 for European Patent Application No. 20855949.2 (16 pages). cited by applicant

International Search Report dated Nov. 30, 2020, issued in corresponding international application No. PCT/US2020/047770, 4 pages. cited by applicant

Suplementary European Search Report Dated Oct. 30, 2023 for European Patent Application No. 20855949.2 (15 pages). cited by applicant

Chinese Office Action issued in corresponding Chinese Application No. 202080054453.6 dated Apr. 10, 2025, 15 pages. cited by applicant

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Background/Summary

TECHNICAL FIELD

(1) The disclosure relates to robotics, and more specifically to robotic surgical devices, assemblies, and/or systems for performing endoscopic surgical procedures and methods of use thereof.

BACKGROUND

(2) Robotic surgical systems have been used in minimally invasive medical procedures. Some robotic surgical systems include a console supporting a surgical robotic arm and a surgical instrument mounted to the robotic arm. The surgical instrument may have an elongated shaft that supports at least one end effector (e.g., forceps or a grasping tool) on a distal end thereof. In some robotic surgical systems, the entire length of the elongated shaft of the surgical instrument must pass through a holder or other feature of the robotic arm, thereby making removal or exchange of the surgical instrument from the robotic arm cumbersome.

(3) Manually-operated surgical instruments often include a handle assembly for actuating the functions of the surgical instrument; however, when using a robotic surgical system, no handle assembly is typically present to actuate the functions of the end effector. It is the robotic arm of the robotic surgical system that provides mechanical power to the surgical instrument for its operation and movement. Each robotic arm may include an instrument drive unit that is operatively connected to the surgical instrument by an interface. The interface couples the selected surgical instrument to the robotic surgical system for driving operations of the surgical instrument and to provide structure for ready removal or exchange of the surgical instrument from the robotic arm.

(4) During a surgical procedure, some portions of the surgical instrument may be exposed to a non-sterile environment or non-sterile components. Such exposure may contaminate the surgical instrument, or portions thereof. Since it is imperative that many of the components of the robotic surgical system remain sterile, there is a need to maintain sterility at the interface used to couple the surgical instrument to the robotic surgical system for protecting sterile components of the robotic surgical system from being contaminated by the non-sterile portions of the surgical instrument. A need also exists for a robotic surgical system that enables more efficient and expeditious removal or exchange of a surgical instrument and which has improved usability.

SUMMARY

(5) In accordance with an aspect of the disclosure, an interface module is provided for coupling an electromechanical robotic surgical instrument to an instrument drive unit. The interface module includes a collar configured to be coupled to the instrument drive unit, a button movably coupled to the collar, and a drive transfer assembly. The drive transfer assembly includes a distal end portion and a proximal end portion movably coupled to the distal end portion. The distal end portion is configured to couple to a driven member of the electromechanical robotic surgical instrument, and the proximal end portion is configured to selectively couple to a drive member of the instrument drive unit. The proximal end portion of the drive transfer assembly is configured to move distally, in response to an actuation of the button, to disengage from the drive member of the instrument

drive unit.
(6) In aspects, the button may be movable along a first axis to move the proximal end portion of the drive transfer assembly along a second axis, perpendicular to the first axis, between an engaged position and a disengaged position. In the engaged position, the drive transfer assembly is engaged with the drive member of the instrument drive unit. In the disengaged position, the drive transfer assembly is disengaged from the drive member of the instrument drive unit.
(7) In some aspects, the interface module may further include a slider supported on the proximal end portion of the drive transfer assembly and configured to engage the button. The proximal end portion of the drive transfer assembly may be configured to move axially with the slider.
(8) In further aspects, the slider may have a camming surface and the button may have a camming surface configured to engage the camming surface of the slider to distally move the slider, and in turn, the proximal end portion of the drive transfer assembly.
(9) In other aspects, the interface module may further include a hub. The hub may house the slider and the proximal end portion of the drive transfer assembly.
(10) In aspects, the instrument drive unit may further include a pull tab movably coupled to the collar and configured to releasably couple the interface module to the instrument drive unit.
(11) In some aspects, the interface module may further include a hub defining an aperture therein. The pull tab may include a protrusion configured to be received in the aperture of the hub to axially fix the hub to the collar.
(12) In further aspects, the pull tab may be manually movable between a first position and a second position. In the first position, the protrusion of the pull tab is engaged with the aperture of the hub whereby the hub is lockingly engaged with the collar. In the second position, the protrusion of the pull tab is disengaged from the aperture of the hub whereby the hub is unlocked from the collar.
(13) In another aspect, the pull tab may be configured to lockingly engage the button when the button is actuated, such that the pull tab maintains the button in an actuated position to maintain the proximal end portion of the drive transfer assembly disengaged from the drive member of the instrument drive unit.
(14) In other aspects, the pull tab may have a latch and the button may have a latch that engages the latch of the pull tab when the button is moved to the actuated position. The latch of the pull tab may be configured to resist movement of the button out of the actuated position.
(15) In aspects, the pull tab may be configured to move between an inward position and an outward position. The latch of the pull tab may be configured to disengage the latch of the button in response to movement of the pull tab toward the outward position.
(16) In some aspects, the interface module may further include a gear selectively engagable with the distal end portion of the drive transfer assembly and manually rotatable to rotate the distal end portion of the drive transfer assembly when the drive transfer assembly is disengaged from the drive member of the instrument drive unit.
(17) In further aspects, the distal end portion of the drive transfer assembly may have gear teeth extending thereabout.
(18) In other aspects, the gear may be slidable relative to the drive transfer assembly between a first position, in which the gear is disengaged from the gear teeth of the distal end portion of the drive transfer assembly, and a second position, in which the gear is engaged with the gear teeth of the distal end portion of the drive transfer assembly.
(19) In another aspect of the disclosure, a sterile interface module for coupling an instrument drive unit and a surgical instrument is provided. The sterile interface module includes a body member configured to selectively couple to a surgical instrument, a hub supported on the body member, a plurality of drive transfer assemblies supported on the body member, and a slider. Each of the drive transfer assemblies includes a proximal end portion configured to selectively couple to a drive member of an instrument drive unit, and a distal end portion configured to selectively couple to a driven member of the surgical instrument. The proximal end portion is axially movable relative to

the distal end portion. The slider is supported on the proximal end portion of each of the drive transfer assemblies. The proximal end portion of the drive transfer assemblies is configured to move distally relative to the respective distal end portion of the drive transfer assemblies to disengage from the respective drive member of the instrument drive unit in response to distal movement of the slider.
(20) In aspects, the slider may define a plurality of openings therethrough. The proximal end portions of the drive transfer assemblies may extend through the respective openings.
(21) In some aspects, the slider may include an end portion having a camming surface.
(22) In further aspects, the sterile interface module may further include a gear rotationally supported on the body member and configured to selectively engage the distal end portion of one of the drive transfer assemblies.
(23) In another aspect, the gear may be slidable relative to the body member between a first position, in which the gear is disengaged from the distal end portion of the drive transfer assembly, and a second position, in which the gear is engaged to the distal end portion of the drive transfer assembly.
(24) In other aspects, hub may have a squared configuration and may include a first side and a second side adjoining the first side. The first side may define a pair of apertures for receipt of a pair of protrusions of a pull tab. The second side may define a passage for receipt of a button.
(25) In accordance with yet another aspect of the disclosure, a sterile interface module is provided and includes a pull tab having a protrusion, a drive transfer assembly, and a hub. The drive transfer assembly is for coupling a driven member of an electromechanical robotic surgical instrument and a drive member of an instrument drive unit. The hub has a portion of the drive transfer assembly disposed therein. The hub defines an aperture configured for receipt of the protrusion of the pull tab. The pull tab is configured to move between a first position and a second position. In the first position, the protrusion of the pull tab is engaged with the aperture of the hub to axially fix the interface module to the instrument drive unit. In the second position, the protrusion of the pull tab is disengaged from the aperture of the hub.
(26) In aspects, the pull tab may be resiliently biased toward the first position.
(27) In some aspects, the sterile interface module may further include a button operably coupled to the drive transfer assembly and configured to disconnect the drive transfer assembly from the drive member of the instrument drive unit when the button is in an actuated position.
(28) In further aspects, the pull tab may be configured to lockingly engage the button, such that the pull tab maintains the button in the actuated position to maintain the drive transfer assembly disconnected from the drive member of the instrument drive unit.
(29) In other aspects, the pull tab may have a latch and the button may have a latch that engages the latch of the pull tab when the button is moved to the actuated position. The latch of the pull tab may be configured to resist movement of the button out of the actuated position.
(30) In another aspect, the pull tab may be configured to move between an inward position and an outward position. The latch of the pull tab may be configured to disengage the latch of the button in response to movement of the pull tab toward the outward position.
(31) Other aspects, features, and advantages will be apparent from the description, the drawings, and the claims that follow.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and, together with a general description of the disclosure given above, and the detailed description given below, serve to explain the principles

of the disclosure, wherein:
(2) FIG. **1** is a schematic illustration of a robotic surgical system including an instrument drive unit, a sterile interface module, and a surgical instrument;
(3) FIG. **2** is a perspective view, with parts separated, of the sterile interface module of FIG. **1**;
(4) FIG. **3** is a top, perspective view of the sterile interface module connected to a drive member of the instrument drive unit of FIG. **1**;
(5) FIG. **4** is a perspective view, with parts separated, of the sterile interface module of FIG. **3**;
(6) FIG. **5** is a perspective view illustrating buttons and pull tabs of the sterile interface module of FIG. **2**;
(7) FIG. **6**A is a transverse cross-sectional view illustrating the pull tabs engaged with a hub of the sterile interface module, and the buttons disengaged from the hub;
(8) FIG. **6**B is a transverse cross-sectional view illustrating the pull tabs disengaged from the hub;
(9) FIG. **7** is a front view of the sterile interface module of FIG. **2** with a release assembly thereof removed for clarity and illustration purposes;
(10) FIG. **8** is a perspective view, with parts shown in phantom, of the sterile interface module of FIG. **7**;
(11) FIG. **9**A is a longitudinal cross-sectional view illustrating the buttons disengaged from a slider of the sterile interface module;
(12) FIG. **9**B is a longitudinal cross-sectional view illustrating one of the buttons engaged with the slider of the sterile interface module;
(13) FIG. **10** is a transverse cross-sectional view illustrating a first gear of the sterile interface module engaged with a first drive transfer assembly of the sterile interface module and a second gear of the sterile interface module disengaged from a second drive transfer assembly of the sterile interface module;
(14) FIG. **11**A is a transverse cross-sectional view, with parts removed, illustrating the buttons in an unlocked state with the pull tabs;
(15) FIG. **11**B is a transverse cross-sectional view, with parts removed, illustrating the buttons in an intermediate position relative to the pull tabs; and
(16) FIG. **11**C is a transverse cross-sectional view illustrating the buttons lockingly engaged with the pull tabs.

DETAILED DESCRIPTION

(17) Embodiments of the disclosure are described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views. As used herein, the term “distal” refers to that portion of the robotic surgical system or component thereof that is closer to a patient, while the term “proximal” refers to that portion of the robotic surgical system or component thereof that is farther from the patient.
(18) As used herein, the terms parallel and perpendicular are understood to include relative configurations that are substantially parallel and substantially perpendicular up to about + or −10 degrees from true parallel and true perpendicular.
(19) As used herein, the term “clinician” refers to a doctor, nurse, or other care provider and may include support personnel. In the following description, well-known functions or construction are not described in detail to avoid obscuring the disclosure in unnecessary detail.
(20) Throughout the disclosure, components of the robotic surgical system described herein may have two or more duplicates thereof. In the interest of brevity, only one of the duplicate components will be described in detail. It can be assumed that the duplicate components not described in detail have identical features and/or functions or substantially identical features and/or functions as its sister component.
(21) Referring initially to FIG. **1**, a surgical system, such as, for example, a robotic surgical system **1**, generally includes one or more surgical robotic arms **2**, **3**, a control device **4**, and an operating console **5** coupled with control device **4**. Any of the surgical robotic arms **2**, **3** may have a robotic

surgical assembly **50** and an electromechanical surgical instrument **60** coupled thereto. The robotic surgical assembly **50** further includes an instrument drive unit **70** and a coupling assembly or sterile interface module **200** that couples the electromechanical surgical instrument **60** to the instrument drive unit **70** as described in greater detail below. In some embodiments, the robotic surgical assembly **50** may be removably attached to a slide rail **40** of one of the surgical robotic arms **2**, **3**. In certain embodiments, the robotic surgical assembly **50** may be fixedly attached to the slide rail **40** of one of the surgical robotic arms **2**, **3**.

(22) Operating console **5** includes a display device **6**, which is set up to display three-dimensional images; and manual input devices **7**, **8**, by means of which a clinician (not shown), is able to telemanipulate the robotic arms **2**, **3** in a first operating mode, as known in principle to a person skilled in the art. Each of the robotic arms **2**, **3** may be composed of any number of members, which may be connected through joints. The robotic arms **2**, **3** may be driven by electric drives (not shown) that are connected to control device **4**. The control device **4** (e.g., a computer) is set up to activate the drives, for example, by means of a computer program, in such a way that the robotic arms **2**, **3**, the attached robotic surgical assembly **50**, and thus the electromechanical surgical instrument **60** (including an electromechanical end effector **60***a* thereof) execute a desired movement according to a movement defined by means of the manual input devices **7**, **8**. The control device **4** may also be set up in such a way that it regulates the movement of the robotic arms **2**, **3** and/or of the drives.

(23) The robotic surgical system **1** is configured for use on a patient "P" positioned (e.g., lying) on a surgical table "ST" to be treated in a minimally invasive manner by means of a surgical instrument such as the electromechanical surgical instrument **60**. The robotic surgical system **1** may also include more than two robotic arms **2**, **3**, the additional robotic arms likewise connected to the control device **4** and telemanipulatable by means of the operating console **5**. A surgical instrument, for example, the electromechanical surgical instrument **60**, may also be attached to any additional robotic arm(s).

(24) The control device **4** may control one or more motors, e.g., motors (Motor **1** . . . n), each motor configured to drive movement of the robotic arms **2**, **3** in any number of directions. Further, the control device **4** may control the instrument drive unit **70** including a motor assembly (not explicitly shown) thereof that drives various operations of the end effector **60***a* of the electromechanical surgical instrument **60**. The motor assembly of the robotic surgical assembly **50** includes any number of motors that couple to the sterile interface module **200** via a corresponding number of drive members **76** (FIG. **3**) extending from the motors.

(25) In general, the robotic surgical assembly **50** transfers power and actuation forces (e.g., torque) from the motors of the motor assembly of the instrument drive unit **70**, through the sterile interface module **200**, to driven members (not explicitly shown) supported within an instrument housing (not explicitly shown) of the electromechanical surgical instrument **60**. Such transfer of power and actuation forces ultimately drives movement of components of the end effector **60***a* of the electromechanical surgical instrument **60** for operating the electromechanical surgical instrument **60**. This movement may include, for example, a movement of a knife blade (not shown) and/or a closing and opening of jaw members (not shown) of the end effector **60***a*, an articulation/rotation/pitch/yaw of the end effector **60***a*, and/or the actuation or firing of the end effector **60***a* (e.g. a stapling portion of the end effector **60***a*).

(26) With reference to FIGS. **2**-**6**B, the sterile interface module **200** of the robotic surgical assembly **50** is provided for selectively interconnecting the robotic surgical assembly **50** and the electromechanical surgical instrument **60**. The electromechanical surgical instrument **60** may be laterally coupled (e.g., side-loaded) to, or laterally decoupled from, the sterile interface module **200** of the robotic surgical assembly **200**. In general, the sterile interface module **200** functions to provide an interface between the instrument drive unit **70** and an electromechanical surgical instrument such as electromechanical surgical instrument **60**. This interface advantageously

maintains sterility, provides a means to transmit electrical communication between the robotic surgical assembly **50** and the electromechanical surgical instrument **60**, provides structure configured to transfer rotational force from the robotic surgical assembly **50** to the electromechanical surgical instrument **60** for performing a function with the electromechanical surgical instrument **60**, and/or provides structure to selectively attach/remove the electromechanical surgical instrument **60** to/from the robotic surgical assembly **50** (e.g., for rapid instrument exchange). In aspects, the interface module **200** may become sterile via a sterilization process performed before or after a procedure and/or be sterilized during manufacturing.

(27) The sterile interface module **200** includes a release assembly **170** coupled to the instrument drive unit **70**, and a main assembly **201** coupled between the release assembly **170** and the surgical instrument **60**. The release assembly **170** is configured to selectively release or detach the main assembly **201** of the sterile interface module **200** from the instrument drive unit **70** and includes a collar or body portion **71**, and a pair of buttons **72**, **74** and a pair of tabs, such as, for example, pull tabs **78**, **80**, each of which being supported in corresponding slots in the collar **71**. The buttons **72**, **74** face opposite one another and are disposed on opposite sides of the collar **71**, and the pull tabs **78**, **80** face opposite one another and are disposed on opposite sides of the collar **71**, such that the buttons **72**, **74** and pull tabs **78**, **80** are all oriented to face a central longitudinal axis "Y" defined by the sterile interface module **200**.

(28) The pull tabs **78**, **80**, which are spring biased by one or more springs **83** (FIG. **6**A) toward an inward position, may be simultaneously pulled to an outward position (FIG. **6**B) to release the main assembly **201** of the sterile interface module **200** from the release assembly **170** of the sterile interface module **200**, and therefore from the instrument drive unit **70**. In some aspects, the release assembly **170** may only include one pull tab. Each of the pull tabs **78**, **80** may have a generally U-shaped configuration and includes a body portion **82**, a stem **84** extending outwardly from the body portion **82**, and a pair of protuberances or protrusions **86**, **88** extending inwardly from the body portion **82**. The stems **84** of the pull tabs **78**, **80** are configured to be grasped by a clinician, and the protrusions **86**, **88** are configured to selectively engage with one or more attachment apertures **246***a*, **246***b* (described in greater detail below) of the sterile interface module **200** to selectively secure the sterile interface module **200** to the instrument drive unit **70**. The protrusions **86**, **88** each have a ramped surface **90**, **93** and a latch feature **92**, such as, for example, a hook, configured to engage with corresponding ramped surfaces **120**, **122** (FIG. **5**) and latch features **126** of the buttons **72**, **74**. In aspects, the ramped surfaces **90**, **93** may be formed on the latch feature **92**.

(29) With the sterile interface module **200** attached to the instrument drive unit **70**, pulling of the pull tabs **78**, **80** outwardly moves the protrusions **86**, **88** of the respective pull tabs **78**, **80** relative to the attachment apertures **246***a*, **246***b* of the sterile interface module **200**, as seen in FIG. **6**B. Such relative movement separates the pull tabs **78**, **80** of the release assembly **170** from a hub **214** of the main assembly **201**, whereby the main assembly **201** can separate from the instrument drive unit **70** (e.g., by pulling the sterile interface module **200** away from the instrument drive unit **70**).

(30) The buttons **72**, **74** of the release assembly **170** are spring biased outwardly by one or more springs **97** (FIG. **6**A) toward a first position, such as, for example, an unactuated position (FIGS. **5**, **6**A). The buttons **72**, **74** may be simultaneously depressed toward a second or actuated position (FIG. **9**B, **11**C) to activate an emergency release mechanism of the sterile interface module **200**, as will be described. In some aspects, the release assembly **170** may only include one button.

(31) Each of the buttons **72**, **74** may have a generally U-shaped configuration and includes a body portion **96** and a pair of protuberances or protrusions **98**, **100** extending inwardly from the body portion **96**. A space **102** is defined between the protrusions **98**, **100** of each of the buttons **72**, **74** for receipt of a block portion **240** of a slider **226** of the sterile interface module **200**. The protrusions **98**, **100** of the buttons **72**, **74** each have a camming surface **104**, such as, for example, an oblique surface, configured to selectively engage with the slider **226** of the sterile interface module **200** to disconnect drive transfer assemblies **222** of the sterile interface module **200** from the drive

members **76** of the instrument drive unit **70**.
(32) Turning now to FIGS. **4** and **7**-**9**B, the main assembly **201** of the sterile interface module **200** generally includes a body member **210**, a coupler assembly **212**, a hub **214** (FIG. **4**), and a slider **226**. The body member **210** has an upper portion **210***a* and a lower portion **210***b* that are coupled together by one or more fasteners such as screws. The sterile interface module **200** includes pins **216** (e.g., pogo pins) that provide electrically conductive pathways through the sterile interface module **200** (e.g., to an end effector **60***a* of a surgical instrument **60** when surgical instrument **60** is coupled to the sterile interface module **200**—see FIG. **1**). The lower portion **210***b* of the body member **210** defines a ramped inner surface **218** configured to support a proximal end of the surgical instrument **60** thereon. The lower portion **210***b* of the body member **210** defines a recess **223** configured to receive an electromechanical surgical instrument, such as electromechanical surgical instrument **60**, therein to removably secure the electromechanical surgical instrument **60** to the robotic surgical assembly **50**. The upper portion **210***a* of the body member **210** defines drive transfer channels **220** that support drive transfer assemblies **222** therein.
(33) The coupler assembly **212** includes the drive transfer assemblies **222**, a support plate **224** (FIG. **4**) on which the drive transfer assemblies **222** are supported, and an actuator, such as, for example, the slider **226**, supported on each of the drive transfer assemblies **222**. As best shown in FIGS. **4**, **9**A, and **9**B, each of the drive transfer assemblies **222** includes a proximal end portion, such as, for example, a proximal shaft **222***a*, and a distal end portion, such as, for example, a distal shaft **222***b*, coupled to the proximal shaft **222***a*. The proximal shaft **222***a* has a coupling end **228** (e.g., a slot) engagable with one of the respective drive shafts **76** (FIG. **3**) of the instrument drive unit **70** on a proximal end of the proximal shaft **222***a*. The proximal shafts **222***a* have a sheath **230** disposed thereabout that defines a ledge **232** on which the slider **226** is supported.
(34) The distal shafts **222***b* of the drive transfer assemblies **222** protrude distally through the respective openings **220** in the body member **210** and are configured to engage corresponding couplers (not shown) of the driven members of the electromechanical surgical instrument **60** (FIG. **1**). The distal shaft **222***b* may be telescopically received in the proximal shaft **222***a* and resiliently biased in a distal direction. As such, the proximal shafts **222***a* float on the distal shafts **222***b* and are configured to move along and relative to the distal shafts **222***b* to selectively couple and decouple their coupling ends **228** from the respective drive shafts **76** of the instrument drive unit **70**, as will be described. The distal shafts **222***b* each have a spur gear **234** fixed thereabout configured to selectively couple to a manual gear **250**, **252** (e.g., a pinion gear) of the sterile interface module **200**. In aspects, any suitable type of gear may be coupled to the distal shafts **222***b*.
(35) The slider **226** of the coupler assembly **212** may have a generally flat, rectangular shape and defines a plurality of openings **236** therethrough. In aspects, the slider **226** may be block-shaped, planar, annular, and/or cylindrical. The openings **236** may be arranged in a squared configuration and have the drive couplers **228** of the proximal shafts **222***a* protruding proximally therefrom. The openings **236** in the slider **226** have a smaller inner diameter than the outer diameter of the sheath **230** of the proximal shafts **222***a*, such that the slider **226** is supported on the ledge **232** of the proximal shafts **222***a*. In this way, distal movement of the slider **226** results in distal movement of the proximal shaft **222***a* along and relative to the respective distal shafts **222***b*.
(36) As best shown in FIGS. **4** and **8**-**9**B, the slider **226** has opposite end portions **226***a*, **226***b* positioned adjacent respective buttons **72**, **74** of the instrument drive unit **70** upon coupling the sterile interface module **200** to the instrument drive unit **70**. The end portions **226***a*, **226** of the slider **226** each have a pair of camming surfaces **237**, **238** and a block **240** disposed between the camming surfaces **237**, **238**. The camming surfaces **237**, **238** are configured to be engaged by the camming surfaces **104** of the buttons **72**, **74**, such that movement of the buttons **72**, **74** along a horizontal axis "X" (FIG. **9**A) drives movement of the slider **226** distally along a vertical axis "Y" defined by the sterile interface module **200**. In aspects, the slider **226** may be axially fixed to the proximal shafts **222***a* in any suitable manner, such as, for example, frictional engagement,

adhesives, fasteners, or the like.

(37) As best shown in FIG. **4**, the hub **214** of the sterile interface module **200** may cover the components of the coupler assembly **212** and function as a connector for mechanically connecting the main assembly **201** of the sterile interface module **200** to the release assembly **170**. The hub **214** has a base **242** fixed to the upper portion **210***a* of the body member **210** and a housing portion **244** attached to an upper surface of the base **242**. The housing **244** of the hub **214** houses therein the slider **226** and the proximal shafts **222***a* of the drive transfer assemblies **222**. The housing **244** of the hub **214** has a square-shaped configuration and includes a first pair of opposite sides **244***a*, **244***b* and a second pair of opposite sides **244***c*, **244***d*. The first pair of opposite sides **244***a*, **244***b* each defines a pair of apertures **246***a*, **246***b* dimensioned for receipt of the protrusions **86**, **88** of the respective pull tabs **78**, **80** for selectively axially fixing the sterile interface module **200** to the instrument drive unit **70**. The second pair of opposite sides **244***c*, **244***d* each defines a passage **248** configured for receipt of the respective buttons **72**, **74** during actuation of the buttons **72**, **74**.

(38) With reference to FIGS. **4**, **8**, and **10**, the sterile interface module **200** includes first and second manual gears **250**, **252**, such as, for example, pinion gears, rotationally and slidably supported on the upper portion **210***a* of the body member **210**. In aspects, the sterile interface module **200** may include one or more manual gears. In further aspects, the sterile interface module **200** may include a manual gear associated with each of the drive transfer assemblies **222**. The manual gears **250**, **252** protrude outwardly through openings **254** in the upper portion **210***a* of the body member **210** to provide a clinician access to the manual gears **250**, **252**. The manual gears **250**, **252** may have an elongate slot **256** defined therein through which a pin **258** is received. The elongate slot **256** allows the gears **250**, **252** to slide between a disengaged position with associated gear teeth **260** of the distal shaft **222***b*, and an engaged position with the associated gear teeth **260** of the distal shaft **222***b*. In aspects, the gears **250**, **252** may be resiliently biased toward the disengaged position by a biasing member (not shown) disposed in the slot **256**. In other aspects, the manual gears **250**, **252** may be permanently fixed in the engaged position.

(39) An operation of the robotic surgical assembly **50** will now be described. With reference to FIGS. **6**A and **6**B, to couple the sterile interface module **200** to the instrument drive unit **70**, the sterile interface module **200** is manipulated in a proximal direction to pass the hub **214** thereof into the collar **71** of the release assembly **170**. The housing portion **244** engages the ramped surfaces **90**, **93** of the pull tabs **78**, **80**, whereby the pull tabs **78**, **80** are moved outwardly, in the direction indicated by arrow "A" in FIG. **6**A, against the resilient bias of the spring members **83**. With the first pair of sides **244***a*, **244***b* of the hub **214** of the sterile interface module **200** aligned with the corresponding pull tabs **78**, **80**, the pull tabs **78**, **80** are biased by the spring members **83** inwardly, in the direction indicated by arrow "B" in FIG. **6**B. The protrusions **86**, **88** of the pull tabs **78**, **80** are received in the corresponding apertures **246***a*, **246***b* in the hub **214** of the sterile interface module **200**, such that the sterile interface module **200** is axially and rotationally fixed to the instrument drive unit **70**. Upon coupling the sterile interface module **200** to the instrument drive unit **70**, the drive couplers **228** of the drive transfer assemblies **222** of the sterile interface module **200** engage the corresponding drive members **76** (FIG. **3**) of the instrument drive unit **70** to operably couple the sterile interface module **200** with the instrument drive unit **70**.

(40) With the robotic surgical assembly **50** of the robotic surgical system **1** secured to one of the surgical robotic arms **2**, **3**, of the robotic surgical system **1**, and the electromechanical surgical instrument **60** of the robotic surgical system **1** secured to the sterile interface module **200** of the robotic surgical system **1**, a clinician can perform a surgical procedure by robotically controlling the driven members of the electromechanical surgical instrument **60** with the motor assembly of the robotic surgical assembly **50** as desired. In particular, one or more of the motors of the motor assembly are actuated to rotate one or more of the drive members **76** of the of the motor assembly so that one or more of the drive transfer assemblies **222** of the sterile interface module **200** cooperate with one or more of the driven members of the electromechanical surgical instrument **60**

to operate and/or manipulate the end effector **60***a* of the electromechanical surgical instrument **60** as desired (e.g., fire, articulate, rotate, etc.).

(41) To decouple the sterile interface module **200** from the instrument drive unit **70**, the release assembly **170** is actuated. In particular, the pull tabs **78**, **80** are moved outwardly, in the direction indicated by arrow "A" in FIG. **6**A, against the resilient bias of the spring members **83** to remove the protrusions **86**, **88** of the pull tabs **78**, **80** from the corresponding apertures **246***a*, **246***b* in the hub **214** of the main assembly **201**. With the pull tabs **78**, **80** of the release assembly **170** disengaged from the hub **214** of the main assembly **201**, the main assembly **201** of the sterile interface module **200** may be disconnected from the instrument drive unit **70**.

(42) With reference to FIGS. **4**, **9**A, and **9**B, in an emergency situation such as when there is an electrical power failure, and when the electromechanical surgical instrument **60** is at least partially positioned within a patient, a manual actuation of the surgical instrument **60** may be performed to manipulate the end effector **60***a* of the surgical instrument **60** despite the absence of power to the robotic surgical system **50**. One or both of the buttons **72**, **74** of the release assembly **170** are depressed to move the buttons **72**, **74** inwardly, in the direction indicated by arrow "C" in FIG. **9**A, from the starting position (FIG. **9**A) toward an actuated position (FIG. **9**B). The camming surfaces **104** of the buttons **72**, **74** engage the camming surfaces **237**, **238** of the slider **226**, whereby the slider **2226** is driven distally, in the direction indicated by arrow "D" in FIG. **9**A. Since the slider **226** is supported on the ledge **232** of the proximal shaft **222***a* of the drive transfer assemblies **222**, the proximal shafts **222***a* move distally with the slider **226** and along the distal shafts **222***b* from an engaged position (FIG. **9**A) to a disengaged position (FIG. **9**B). In the disengaged position, the drive couplers **228** of the proximal shafts **222***a* are spaced distally from the drive shafts **76** (FIG. **3**) of the instrument drive unit **70**, and therefore not engaged therewith.

(43) With reference to FIGS. **11**A-**11**C, concurrently with the buttons **72**, **74** engaging the slider **226**, ramped surfaces **120**, **122** defined on the respective protrusions **98**, **100** of the buttons **72**, **74** engage the ramped surfaces **90**, **93** of the pull tabs **78**, **80** (FIG. **11**A) to drive the pull tabs **78**, **80** outwardly, as shown in FIG. **11**B. Continued application of an actuation force on the buttons **72**, **74** moves the buttons **72**, **74** to the actuated position, as shown in FIG. **11**C. In the actuated position, the latches **126** of the buttons **72**, **74** engage the latches **92** of the pull tabs **78**, **80**, whereby the pull tabs **78**, **80** resist movement of the buttons **72**, **74** out of the actuated position. In this way, a clinician does not have to maintain a force on the buttons **72**, **74** to keep the buttons **72**, **74** in the actuated position, in which the drive transfer assemblies **222** are disengaged from the drive members **76** of the instrument drive unit **70**. With the drive transfer assemblies **222** maintained in the disengaged position by the connection between the pull tabs **78**, **80** and the buttons **72**, **74**, a clinician may manually actuate the surgical instrument **60**.

(44) In particular, as shown in FIG. **10**, one of the gears **250**, **252** of the sterile interface module **200** may be pushed inwardly into engagement with gear teeth of **260** the distal shaft **222***b*. With one of the gears **250**, **252** operably coupled with the distal shaft **222***b*, the gear **250** may be rotated, e.g., using a thumb of a clinician or any other suitable manner. Rotation of the gear **250** causes the associated distal shaft **222***b* to rotate, whereby the distal shaft **222***b* imparts forces (e.g., torque) through the respective components of the electromechanical surgical instrument **60** to manually manipulate the end effector **60***a* (FIG. **1**) of the electromechanical surgical instrument **60** to position the end effector **60***a* in a desired orientation/position. For example, the end effector **60***a* of the electromechanical surgical instrument **60** can be manually manipulated to an open position to release tissue grasped by the end effector **60***a* so that the electromechanical surgical instrument **60** can be removed from a surgical site while limiting the risks of undesirable tissue damage that would otherwise be if such manual manipulation were not feasible when a power failure or other similar emergency situation arises.

(45) Persons skilled in the art will understand that the structures and methods specifically described herein and shown in the accompanying figures are non-limiting exemplary embodiments, and that

the description, disclosure, and figures should be construed merely as exemplary of particular embodiments. It is to be understood, therefore, that the disclosure is not limited to the precise embodiments described, and that various other changes and modifications may be effected by one skilled in the art without departing from the scope or spirit of the disclosure. Additionally, the elements and features shown or described in connection with certain embodiments may be combined with the elements and features of certain other embodiments without departing from the scope of the disclosure, and that such modifications and variations are also included within the scope of the disclosure. Accordingly, the subject matter of the disclosure is not limited by what has been particularly shown and described.

Claims

1. An interface module for selective coupling between an electromechanical robotic surgical instrument and an instrument drive unit, the interface module comprising: a collar configured to be coupled to the instrument drive unit; a button supported by and movably coupled to the collar; a drive transfer assembly including: a distal end portion configured to couple to a driven member of the electromechanical robotic surgical instrument; and a proximal end portion movably coupled to the distal end portion and configured to selectively couple to a drive member of the instrument drive unit, wherein the proximal end portion of the drive transfer assembly is configured to move distally, in response to an actuation of the button, to disengage from the drive member of the instrument drive unit; and a gear selectively engageable with the distal end portion of the drive transfer assembly and manually rotatable to rotate the distal end portion of the drive transfer assembly when the drive transfer assembly is disengaged from the drive member of the instrument drive unit.
2. The interface module according to claim 1, wherein the button is movable along a first axis to move the proximal end portion of the drive transfer assembly along a second axis, perpendicular to the first axis, between an engaged position, in which the drive transfer assembly is engaged with the drive member of the instrument drive unit and a disengaged position, in which the drive transfer assembly is disengaged from the drive member of the instrument drive unit.
3. The interface module according to claim 1, wherein the interface module further includes a slider supported on the proximal end portion of the drive transfer assembly and configured to engage the button, the proximal end portion of the drive transfer assembly being configured to move axially with the slider.
4. The interface module according to claim 3, wherein the slider has a camming surface and the button has a camming surface configured to engage the camming surface of the slider to distally move the slider, and in turn, the proximal end portion of the drive transfer assembly.
5. The interface module according to claim 3, further comprising a hub, wherein the slider and the proximal end portion of the drive transfer assembly are housed within the hub.
6. The interface module according to claim 1, further comprising a pull tab movably coupled to the collar and configured to releasably couple the interface module to the instrument drive unit.
7. The interface module according to claim 6, further comprising a hub defining an aperture therein, wherein the pull tab includes a protrusion configured to be received in the aperture of the hub to axially fix the hub to the collar.
8. The interface module according to claim 7, wherein the pull tab is manually movable between a first position, in which the protrusion of the pull tab is engaged with the aperture of the hub whereby the hub is lockingly engaged with the collar, and a second position, in which the protrusion of the pull tab is disengaged from the aperture of the hub whereby the hub is unlocked from the collar.
9. The interface module according to claim 6, wherein the pull tab is configured to lockingly engage the button when the button is actuated, such that the pull tab maintains the button in an

actuated position to maintain the proximal end portion of the drive transfer assembly disengaged from the drive member of the instrument drive unit.
10. The interface module according to claim 9, wherein the pull tab has a latch and the button has a latch that engages the latch of the pull tab when the button is moved to the actuated position, the latch of the pull tab being configured to resist movement of the button out of the actuated position.
11. The interface module according to claim 10, wherein the pull tab is configured to move between an inward position and an outward position, the latch of the pull tab being configured to disengage the latch of the button in response to movement of the pull tab toward the outward position.
12. The interface module according to claim 1, wherein the distal end portion of the drive transfer assembly has gear teeth extending thereabout.
13. The interface module according to claim 12, wherein the gear is slidable relative to the drive transfer assembly between a first position, in which the gear is disengaged from the gear teeth of the distal end portion of the drive transfer assembly, and a second position, in which the gear is engaged with the gear teeth of the distal end portion of the drive transfer assembly.
14. A sterile interface module for selective coupling between an instrument drive unit and a surgical instrument, the sterile interface module comprising: a body member configured to selectively couple to the surgical instrument; a hub supported on the body member; a plurality of drive transfer assemblies supported on the body member, each of the plurality of drive transfer assemblies being rotatable about a respective axis thereof; each of the plurality of drive transfer assemblies including: a proximal end portion configured to selectively couple to a drive member of the instrument drive unit; and a distal end portion configured to selectively couple to a driven member of the surgical instrument, the proximal end portion being axially movable relative to the distal end portion; and a slider supported on the proximal end portion of each of the plurality of drive transfer assemblies and slidable in a direction parallel to the axis of rotation of each drive transfer assembly, wherein the proximal end portions for all of the drive transfer assemblies move distally relative to the respective distal end portion of the plurality of drive transfer assemblies to disengage from the respective drive member of the instrument drive unit in response to distal movement of the slider.
15. The sterile interface module according to claim 14, wherein the slider defines a plurality of openings therethrough, the proximal end portion of each of the plurality of drive transfer assemblies extending through the respective opening.
16. The sterile interface module according to claim 14, wherein the slider includes an end portion having a camming surface.
17. The sterile interface module according to claim 14, further comprising a gear rotationally supported on the body member and configured to selectively engage the distal end portion of at least one of the plurality of drive transfer assemblies.
18. The sterile interface module according to claim 17, wherein the gear is slidable relative to the body member between a first position, in which the gear is disengaged from the distal end portion of the at least one of the plurality of drive transfer assemblies, and a second position, in which the gear is engaged to the distal end portion of the at least one of the plurality of drive transfer assemblies.
19. The sterile interface module according to claim 14, wherein the hub has a squared configuration and includes a first side defining a pair of apertures for receipt of a pair of protrusions of a pull tab, and a second side adjoining the first side and defining a passage for receipt of a button.
20. A sterile interface module for selective coupling between an electromechanical robotic surgical instrument and an instrument drive unit, the sterile interface module comprising: a pull tab having a protrusion; and a drive transfer assembly for coupling a driven member of the electromechanical robotic surgical instrument and a drive member of the instrument drive unit; and a hub having at least a portion of the drive transfer assembly disposed therein, the hub defining an aperture, the protrusion of the pull tab being disposed within the aperture of the hub, wherein the pull tab is

configured to move between a first position, in which the protrusion of the pull tab is engaged with the aperture of the hub to axially fix the sterile interface module to the instrument drive unit, and a second position, in which the protrusion of the pull tab is disengaged from the aperture of the hub.

21. The sterile interface module according to claim 20, wherein the pull tab is resiliently biased toward the first position.

22. The sterile interface module according to claim 20, further comprising a button operably coupled to the drive transfer assembly and configured to disconnect the drive transfer assembly from the drive member of the instrument drive unit when the button is in an actuated position.

23. The sterile interface module according to claim 22, wherein the pull tab is configured to lockingly engage the button, such that the pull tab maintains the button in the actuated position to maintain the drive transfer assembly disconnected from the drive member of the instrument drive unit.

24. The sterile interface module according to claim 23, wherein the pull tab has a latch and the button has a latch that engages the latch of the pull tab when the button is moved to the actuated position, the latch of the pull tab being configured to resist movement of the button out of the actuated position.

25. The sterile interface module according to claim 24, wherein the pull tab is configured to move between an inward position and an outward position, the latch of the pull tab being configured to disengage the latch of the button in response to movement of the pull tab toward the outward position.