

SURGEON INPUT DEVICE FOR MINIMALLY INVASIVE SURGERY

TECHNICAL FIELD

5 **[0001]** The present disclosure generally relates to the field of robotic surgical system for minimally invasive surgery, and more particularly, the disclosure relates to a surgeon input device for directing movement of the robotic assisted surgical system in a minimally invasive surgical procedure.

BACKGROUND

10 **[0002]** This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described below. This disclosure is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not just as an admissions of prior art.

15 **[0003]** Robotic assisted surgical systems have been adopted worldwide to gradually replace conventional surgical procedures such as open surgery and laparoscopic surgical procedures. The robotic assisted surgery offers various benefits to a patient during surgery and during post-surgery recovery time. The robotic assisted surgery equally offers numerous benefits to a surgeon in terms of
20 enhancing the surgeon's ability to precisely perform surgery, less fatigue and a magnified clear three-dimensional (3D) vision of a surgical site. Further, in a robotic assisted surgery, the surgeon typically operates with a hand controller/master controller/ surgeon input device/joystick at a surgeon console system to seamlessly capture and transfer complex actions performed by him/her giving the
25 perception that he/she himself/herself is directly articulating a surgical tool/surgical instrument to perform the surgery.

[0004] The robotically assisted surgical systems may comprise of multiple modular robotic arms aiding in conducting robotic assisted surgeries. The surgeon controls the robotic arms, and the instruments mounted on it by using the

surgeon console. The surgeon console comprises of visualization system to allow the surgeon to perform the surgery. Further, the hand controllers/ the master controllers/ the surgeon input devices are integrated with the surgeon console which the surgeon maneuvers to perform the surgery. The surgeon operating on the surgeon console system may be located at a distance from a surgical site or may be located within an operating theatre where the patient is being operated on.

[0005] Performing surgery at the surgeon console creates new challenges. During surgery, the surgeon often requires to be seated into an exhaustive posture for many hours due to the hardware structure of such surgeon consoles.

[0006] The main challenge with the existing surgeon input device is that the control to activate and deactivate the surgeon command through the surgeon input device is done by pressing a clutch pedal in the foot pedal assembly. This leads to committing a mistake in pressing the wrong pedal in the existing close console robotic surgical systems and fatigue to the surgeon.

[0007] Further, another challenge is that in the existing multi-arm robotic surgical systems, there was no provision of preventing the transfer of motion of the surgeon input device to the surgical instrument in case of an accidental drop from the hand of a surgeon.

[0008] Moreover, another challenge is that the existing surgeon input device was not able to detect the palm grip of a surgeon for each motion of surgeon's hand while holding the surgeon input device.

[0009] Furthermore, another challenge is that it is difficult to repose the surgeon's hand within the workspace of the surgeon input device during an ongoing surgery, without moving the respective robotic surgical instrument.

[00010] In the light of the above-mentioned challenges, there is a need for a robotic surgical system with an improved surgeon input device, such as a sensor-based surgeon input device for using a multi-arm robotic surgical system, which will solve the above-mentioned problems related to robotic surgeries.

SUMMARY OF THE DISCLOSURE

[00011] Some or all of the above-mentioned problems related to a surgeon input device are proposed to be addressed by certain embodiments of the present disclosure.

[00012] According to an aspect of the invention, there is disclosed a surgeon input device for controlling a robotic surgical system comprising a plurality of robotic arms, out of which one arm coupled to an endoscopic camera, the remaining arms are connected to robotic surgical instruments, and a surgeon console having a control processor, the surgeon input device comprising: a housing configured to be held in a surgeon's hand; a pinch button on the housing, the pinch button configured to be pressed/released by a surgeon's finger to close/open a jaw of an end-effector of any surgical instrument; a clutch button located on the housing, the clutch button configured to repose the surgeon's hand within a workspace of the surgeon input device, without moving the respective robotic surgical instrument; a plunger connected beneath the pinch button, the plunger configured to provide a mechanical force feedback to the surgeon's upon pressing of the pinch button by applying a certain predefined force; at least one sensor disposed inside the housing, the at least one sensor configured to detect a compression and decompression of the pinch button by the surgeon's finger and send a signal to the console processor to control the opening and closing of the jaws of the end effector of the respective robotic surgical instruments; at least one sensor disposed within the housing, configured to detect the presence of the surgeon's hand and send a signal to the console processor to activate the robotic surgical system; and at least one sensor disposed within the housing, the at least one sensor operably coupled to an electromagnetic wave generator, the at least one sensor configured to detect at least one of a position and orientation of a surgeon's hand within a predefined electromagnetic field generated by the electromagnetic wave generator and send a signal to the console processor; wherein the plunger provides the mechanical force feedback to the surgeon's hand by applying a force on the surgeon's finger to give a feeling or an indication that a tissue or vessel has been held by the jaws of the respective surgical instrument, wherein after receiving the mechanical force feedback, the pinch button can be presses harder to cut the

tissue/vessel; wherein a number and position of the at least one sensor is optimized such that for each motion of the surgeon's hand using the surgeon input device, at least one of the sensors detects the presence of the surgeon's hand.

5 **[00013]** According to an embodiment of the invention, the electromagnetic sensor sends a signal to a control system in the console processor for transforming motion of the surgeon's hand into motion of the end-effector of the surgical instruments.

[00014] According to another embodiment of the invention, the sensors may be any one of an infrared sensor, a capacitive sensor, and the like.

10 **[00015]** According to yet another embodiment of the invention, the sensor may be any one of a Hall sensor, a reed switch, a proximity sensor, and the like.

[00016] According to yet another embodiment of the invention, the surgeon input device can be connected to the surgeon console using a wired
15 connection.

[00017] According to yet another embodiment of the invention, the surgeon input device may be wirelessly connected to the surgeon console by means of Bluetooth, ZigBee and the like.

[00018] According to still another embodiment of the invention, in the
20 wireless mode, a power source such as a battery may be embedded inside the housing of the surgeon input device.

[00019] According to still another embodiment of the invention, the clutch button can be used along with a camera clutch to perform functions like camera zoom-in and zoom-out.

25 **[00020]** According to still another embodiment of the invention, the default or normal position of the pinch button is the open position.

[00021] According to still another embodiment of the invention, a spring provided in the surgeon input device facilitates the pinch button to come back to its normal position.

30 **[00022]** Other embodiments, systems, methods, apparatus aspects, and features of the invention will become apparent to those skilled in the art from the

following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [00023] The summary above, as well as the following detailed description of the disclosure, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the present disclosure is not limited to specific methods and instrumentalities disclosed herein. Moreover, those skilled in the art will understand that the
10 drawings are not to the scale. Wherever possible, like elements have been indicated by identical numbers.

Embodiments of the present disclosure will now be described, by way of example only, with reference to the following diagrams wherein:

15 **Figure 1** illustrates an example implementation of a multi-arm teleoperated robotic surgical system which can be used with one or more features in accordance with an embodiment of the disclosure;

Figure 2 illustrates a schematic diagram of a surgeon console of the robotic surgical system in accordance with an embodiment of the disclosure;

20 **Figures 3(a)-3(b)** illustrate a surgeon input device in accordance with an embodiment of the disclosure; and

Figure 4 illustrates an internal view of a surgeon input device in accordance with an embodiment of the disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

25 [00024] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended, such alterations and further modifications in the illustrated system, and such further applications of the principles of the disclosure as
30 illustrated therein being contemplated as would normally occur to one skilled in

the art to which the disclosure relates.

[00025] It will be understood by those skilled in the art that the foregoing general description and the following detailed description are exemplary and explanatory of the disclosure and are not intended to be restrictive thereof. Throughout the patent specification, a convention employed is that in the appended drawings, like numerals denote like components.

[00026] Reference throughout this specification to “an embodiment”, “another embodiment”, “an implementation”, “another implementation” or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, appearances of the phrase “in an embodiment”, “in another embodiment”, “in one implementation”, “in another implementation”, and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[00027] The terms “comprises”, “comprising”, or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a process or method that comprises a list of steps does not include only those steps but may include other steps not expressly listed or inherent to such process or method. Similarly, one or more devices or sub-systems or elements or structures preceded by “comprises... a” does not, without more constraints, preclude the existence of other devices or other sub-systems or other elements or other structures or additional devices or additional sub-systems or additional elements or additional structures.

[00028] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. The device, system, and examples provided herein are illustrative only and not intended to be limiting.

[00029] The terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items. Further, the term sterile barrier and sterile adapter denotes the same meaning and may be used interchangeably throughout the description.

[00030] Embodiments of the disclosure will be described below in detail with reference to the accompanying drawings.

[00031] Figure 1 illustrates an example implementation of a multi-arm teleoperated robotic surgical system which can be used with one or more features in accordance with an embodiment of the disclosure. Specifically, Figure 1 illustrates a multi arm robotic surgical system (100) having five robotic arms (102a), (102b), (102c), (102d), (102e) mounted on five robotic arm carts arranged around an operating table (104). The five-robotic arms (102a), (102b), (102c), (102d), (102e) (as depicted in Figure 1) are for illustration purposes and the number of robotic arms may vary depending upon the type of surgery. The five robotic arms (102a), (102b), (102c), (102d), (102e) may also be arranged in any different manner not limited to the robotic arms (102a), (102b), (102c), (1012d), (102e) arranged along the operating table (104). The robotic arms (102a), (102b), (102c), (102d), (102e) may be separately mounted on the five robotic arm carts or the robotic arms (102a), (102b), (102c), (102d), (102e) mechanically and/ or electronically connected with each other or the robotic arms (102a), (102b), (102c), (102d), (102e) connected to a central body (not shown) such that the robotic arms (102a), (102b), (102c), (102d), (102e) branch out of a central body (not shown). Further, the multi arm teleoperated robotic surgical system (100) may include an accessory table (106) for surgical instruments, a vision cart (108), and a surgeon console system (110). An endoscopic camera (C) is connected to the robotic arms (102c), and robotic surgical instruments (RSI1, RSI2, RSI3, RSI4) are connected to remaining robotic arms (102a), (102b), (102d), (102e).

[00032] Figure 2 illustrates a schematic diagram of a surgeon console of the robotic surgical system in accordance with an embodiment of the disclosure. The surgeon console (110) aids the surgeon to remotely operate the patient lying on the operating table (104) by controlling various surgical instruments (RSI1, RSI2, RSI3, RSI4) and endoscopic camera (C) mounted on the robotic arms (102a), (102b), (102d), (102e) and (102c) respectively. The surgeon console (110) has a console processor (118), which is configured to control the movement of surgical instruments (RSI1, RSI2, RSI3, RSI4) while the instruments are inside

the patient body (as shown in Figure 2). The surgeon console (110) may comprise of at least an adjustable viewing means (112) and (114) but not limited to 2D/ 3D monitors, wearable viewing means (116) and in combination thereof. The surgeon console (110) may be equipped with multiple displays which would not only show 3D high definition (HD) endoscopic view of a surgical site at the operating table (104) but may also show additional information from various medical equipment's which surgeon may need during the robotic surgery. Further, the viewing means (112) and (114) may provide various modes of the robotic surgical system (100) but not limited to identification of number of robotic arms attached, current surgical instruments type attached, current instruments end effector tip position, collision information along with medical data like ECG, ultrasound display, fluoroscopic images, CT, MRI information and the like.

[00033] The surgeon (not shown) has to wear a pair of trackable 3D glasses (116) to use with the surgeon console (110). The surgeon's pair of trackable 3D glasses (116) are tracked with a sensing device like a head tracking camera (120) which can be secured to the 3D HD monitor (112). Preferably, the head tracking camera (120) can be secured to the top of the 3D HD monitor (112). This is a safety feature to avoid distracted use of the multi-arm robotic surgical system (100) for robotic surgery and unintended motions while the surgeon's attention is not focused on the 3D HD Monitor (112). The surgeon input device (122, 124) at the surgeon console (110) is required to seamlessly capture and transfer complex actions performed by surgeon giving the perception that the surgeon is directly articulating the surgical tools. The different types of surgeon input devices can be utilized for performing a surgical robotic procedure. In some embodiments, the surgeon input devices (122, 124) may be one or more manually operated input devices, such as a joystick, exoskeletal glove, a powered and gravity- compensated manipulator, or the like. These surgeon input devices (122, 124) control the motors connected in the actuator unit, which, in turn, control the movement of the surgical instruments (RSI1, RSI2, RSI3, RSI4) attached to the robotic arms.

[00034] The chair (not shown) may be adjustable with means in height,

elbow rest and the like according to the ease of the surgeon and also various control means may be provided on the chair. Further, the surgeon console (110) may be at a single location inside an operation theatre or may be distributed at any other location in the hospital provided connectivity to the robotics arms is maintained.

5 A data related to movement of surgeon input devices (122, 124) by the surgeon, a data from various foot toggle switches (126), clutch mechanism (128), and any other sensor-based data for robotic surgical instruments are communicated to the console processor (118). The surgeon input devices (122) and (124) may be used by left hand and right hand respectively. Both the surgeon input devices (122) and
10 (124) are identical.

[00035] Figures 3(a)-3(b) illustrate a surgeon input device in accordance with an embodiment of the invention. In the description, the surgeon input device (122) and (124) may be referred to as a surgeon input device (300). The surgeon input device (300) may include a housing (302), a pinch button (304), a plurality
15 of sensors (308a, 308b, 308c), and a clutch button (306). The sensors (308a, 308b, 308c) may be any one of an infrared (IR) sensor, a capacitive sensor, and the like.

[00036] Figure 4 illustrates an internal view of a surgeon input device in accordance with an embodiment of the invention. The housing (302) as shown in Figure 3(a)-3(b) is removed so that internal components of the surgeon hand input
20 device (300) can be seen. The components and functionality of the surgeon input device for both the left and right hands may be the same. The pinch button (304) may be pressed by surgeon's finger to close a jaw of an end-effector of any surgical instruments (RSI1, RSI2, RSI3, RSI4). The jaws may open when the surgeon's finger releases the pinch button (304). Further, a sensor (310) and a magnet (312),
25 are disposed within the housing (302) to sense the compression and decompression of the pinch button (304) by the surgeon's hand, to control the opening and closing of the jaws of the end effectors of the surgical instruments (RSI1, RSI2, RSI3, RSI4). When the surgeon releases the pinch button (304), the spring (318) facilitates the pinch button (304) to come back to its normal position. The default
30 or normal position of the pinch button (304) is the open position. The sensor (310) may be any magnetic sensor, like a Hall sensor, a reed switch, a proximity sensor,

and the like.

[00037] An electromagnetic sensor (314) is provided in the housing (302) and an electromagnetic wave generator (130) is provided in the surgeon console (110). The electromagnetic sensor (314) detects at least one of a position and orientation of a surgeon's hand within a predefined electromagnetic field generated by the electromagnetic wave generator (130) and sends a signal to a control system in the console processor (118) for transforming motion of the surgeon's hand into motion of the end-effector of the surgical instruments, instruments actuator and the robotic arm. The surgeon input device (300) is connected to the surgeon console (110) using a wired connection. The surgeon input device (300) may also be wirelessly connected to the surgeon console (110) by means of Bluetooth, ZigBee and the like. In wireless mode, a power source such as a battery may be embedded inside the housing (302) of the surgeon input device (300).

[00038] A clutch button (306) is provided on the housing of the surgeon input device (300). The clutch button (306) has multiple uses. The clutch button (306) can be used along with a camera clutch (not shown) to perform functions like camera zoom-in and zoom-out. Further, during a surgery, the pressing of the clutch button (306) allows the surgeon to repose his/her hand, without moving the surgical instrument and lets the surgeon to be in a comfortable position. Also, the pressing of the clutch button (306) allows the surgeon's hand to be within the workspace of surgeon input device.

[00039] A plunger (316) is disposed in the surgeon input device (300). Whenever the surgeon wants to hold a tissue or a vessel inside a patient's body, the surgeon will press the pinch button (304) by applying a certain predefined force. However, if the surgeon applies extra force on the pinch button (304) which is more than the desired force for holding the tissue or vessel then the plunger (316) will apply a force on the surgeon's hand to give a feeling or indication that the tissue or vessel has been held by the jaws of the respective surgical instrument. The plunger (316) provides a mechanical force feedback to the hand of the surgeon. If the surgeon wants to cut or grab the tissue or vessel, then the surgeon

can press the pinch button (304) harder.

5 **[00040]** As shown in figure 3(a)-3(b), multiple infrared (IR) sensors (308a), (308b), (308c) are provided in the surgeon input device (300). The number and positions of IR sensors (308a), (308b), (308c) is optimized such that for each motion of the surgeon's hand using the surgeon input device (300), at least one of the IR sensors (308a), (308b), (308c) detects the presence of surgeon's hand. In an alternate embodiment, a capacitive sensor (not shown) may be used in place of IR sensors to detect the presence of surgeon's hand. When surgeon holds the surgeon input device (300), the multiple infrared (IR) sensors detect the presence of surgeon's hand and send signal to activate the robotic surgical system (100).
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[00041] In a multi-arm robotic surgical system, while performing a surgical procedure, the surgeon may have to use more than two surgical instruments at various points in time. If the surgeon is using a surgical instrument in a robotic arm on the left side and another surgical instrument in the right-side arm, and then to perform a certain surgical action, the surgeon may want to switch between the arms either on the left side or right side. This can be achieved by pressing the respective toggle switches (128) provided in the surgeon console (110).
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[00042] The present disclosure has the following advantages: The surgeon input device of the present disclosure has an ergonomic design. Further, the surgeon input device of the present disclosure is very easy to hold and use. Further, it does not give fatigue to a surgeon's hands during prolonged use in surgery. Also, if the surgeon input device gets dropped by mistake from a surgeon's hands or it is kept on the stand of surgeon command center, then the control system in the console processor (118) freezes the movement of the surgical instrument. In addition, for each motion of the surgeon's hands, the holding of the surgeon input device in the palm of the surgeon may be easily detected. Moreover, the surgeon input device is provided with a safety feature of providing a mechanical feedback to the surgeon, so as to avoid an accidental application of extra force on the pinch button by the surgeon which may lead to cutting the vessel or tissue.
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[00043] The foregoing descriptions of exemplary embodiments of the present disclosure have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the disclosure to the precise forms disclosed, and obviously many modifications and variations are possible in
5 light of the above teaching. The exemplary embodiment was chosen and described in order to best explain the principles of the disclosure and its practical application, to thereby enable others skilled in the art to best utilize the disclosure and various embodiments with various modifications as are suited to the particular use contemplated. It is understood that various omissions, substitutions of equivalents
10 are contemplated as circumstance may suggest or render expedient but is intended to cover the application or implementation without departing from the spirit or scope of the claims of the present disclosure.

[00044] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits,
15 advantages, solutions to problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.

[00045] While specific language has been used to describe the
20 disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art, various working modifications may be made to the apparatus in order to implement the inventive concept as taught herein.

WE CLAIM:

1. A surgeon input device (300) for controlling a robotic surgical system (100) comprising a plurality of robotic arms (102a), (102b), (102c), (102d), (102e), out of which one arm (102c) coupled to an endoscopic camera (C), the remaining arms
5 are connected to robotic surgical instruments (RSI1, RSI2, RSI3, RSI4), and a surgeon console (110) having a control processor (118), the surgeon input device (300) comprising:

a housing (302) configured to be held in a surgeon's hand;

a pinch button (304) on the housing (302), the pinch button (304) configured
10 to be pressed/released by a surgeon's finger to close/open a jaw of an end-effector of any surgical instrument (RSI1, RSI2, RSI3, RSI4);

a clutch button (306) located on the housing (302), the clutch button (306) configured to repose the surgeon's hand within a workspace of the surgeon input device (300), without moving the respective robotic surgical instrument (RSI1,
15 RSI2, RSI3, RSI4);

a plunger (316) connected beneath the pinch button (304), the plunger (316) configured to provide a mechanical force feedback to the surgeon's upon pressing of the pinch button (304) by applying a certain predefined force;

at least one sensor (310) disposed inside the housing (302), the at least one
20 sensor (310) configured to detect a compression and decompression of the pinch button (304) by the surgeon's finger and send a signal to the console processor (118) to control the opening and closing of the jaws of the end effector of the respective robotic surgical instruments (RSI1, RSI2, RSI3, RSI4);

at least one sensor (308a), (308b), (308c) disposed within the housing (302),
25 configured to detect the presence of the surgeon's hand and send a signal to the console processor (118) to activate the robotic surgical system (100); and

at least one sensor (314) disposed within the housing (302), the at least one sensor (314) operably coupled to an electromagnetic wave generator (130), the at

least one sensor (314) configured to detect at least one of a position and orientation of a surgeon's hand within a predefined electromagnetic field generated by the electromagnetic wave generator (130) and send a signal to the console processor (118);

5 wherein the plunger (316) provides the mechanical force feedback to the surgeon's hand by applying a force on the surgeon's finger to give a feeling or an indication that a tissue or vessel has been held by the jaws of the respective surgical instrument (RSI1, RSI2, RSI3, RSI4),

 wherein after receiving the mechanical force feedback, the pinch button
10 (304) can be pressed harder to cut the tissue/vessel;

 wherein a number and position of the at least one sensor (308a), (308b), (308c) is optimized such that for each motion of the surgeon's hand using the surgeon input device (300), at least one of the sensors (308a), (308b), (308c) detects the presence of the surgeon's hand.

15 2. The surgeon input device (300) as claimed in claim 1, wherein the electromagnetic sensor (314) sends a signal to a control system in the console processor (118) for transforming motion of the surgeon's hand into motion of the end-effector of the surgical instruments (RSI1, RSI2, RSI3, RSI4).

 3. The surgeon input device (300) as claimed in claim 1, wherein the sensors
20 (308a, 308b, 308c) may be any one of an infrared (IR) sensor, a capacitive sensor, and the like.

 4. The surgeon input device (300) as claimed in claim 1, wherein the sensor (310) may be any one of a Hall sensor, a reed switch, a proximity sensor, and the like.

25 5. The surgeon input device (300) as claimed in claim 1, wherein the surgeon input device (300) can be connected to the surgeon console (110) using a wired connection.

6. The surgeon input device (300) as claimed in claim 1, wherein the surgeon input device (300) may be wirelessly connected to the surgeon console (110) by means of Bluetooth, ZigBee and the like.

5 7. The surgeon input device (300) as claimed in claim 1, wherein in the wireless mode, a power source such as a battery may be embedded inside the housing (302) of the surgeon input device (300).

8. The surgeon input device (300) as claimed in claim 1, wherein the clutch button (306) can be used along with a camera clutch to perform functions like camera zoom-in and zoom-out.

10 9. The surgeon input device (300) as claimed in claim 1, wherein the default or normal position of the pinch button (304) is the open position.

10. The surgeon input device (300) as claimed in claim 1, wherein a spring (318) provided in the surgeon input device (300) facilitates the pinch button (304) to come back to its normal position.

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