US010324540B1

(12) **United States Patent**
Parazynski

(10) **Patent No.: US 10,324,540 B1**
(45) **Date of Patent: Jun. 18, 2019**

(54) **MULTI-DEGREES-OF-FREEDOM HAND CONTROLLER**

(71) Applicant: **Fluidity Technologies, Inc.**, Houston, TX (US)

(72) Inventor: **Scott Edward Parazynski**, Houston, TX (US)

(73) Assignee: **Fluidity Technologies, Inc.**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/248,597**

(22) Filed: **Jan. 15, 2019**

Related U.S. Application Data

(63) Continuation of application No. 15/394,490, filed on Dec. 29, 2016, which is a continuation of application
(Continued)

(51) **Int. Cl.**
A61B 5/00 (2006.01)
A61B 34/00 (2016.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 3/0346*** (2013.01); ***A61B 34/30*** (2016.02); ***A61B 34/37*** (2016.02); ***A61B 34/74*** (2016.02);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/0346; G06F 3/0338; A61B 34/00; A61B 34/37; A61B 34/74; A61B 5/7475;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,260,826 A 7/1966 Johnson
4,012,014 A * 3/1977 Marshall B64C 13/04 244/234

(Continued)

FOREIGN PATENT DOCUMENTS

JP H11-154031 6/1999

OTHER PUBLICATIONS

Office Action for U.S. Appl. No. 13/797,184, dated Mar. 2, 2015, 16 pages.

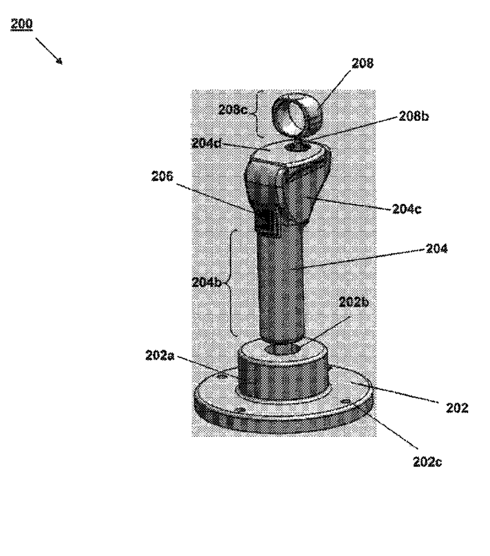
(Continued)

Primary Examiner — Joseph H Feild
Assistant Examiner — Rufus C Point

(57) **ABSTRACT**

Disclosed is a controller including a first control member, a second control member that extends from a portion of the first control member, and a controller processor that is operable to produce a rotational movement output signal in response to movement of the first control member, and a translational movement output signal in response to movement of the second control member relative to the first control member. The rotational movement output signal may be any of a pitch movement output signal, a yaw movement output signal, and a roll movement output signal, and the translational movement output signal may be any of an x-axis movement output signal, a y-axis movement output signal, and a z-axis movement output signal. In exemplary embodiments, the first control member may be gripped and moved using a single hand, and the second control member may be moved using one or more digits of the single hand, thus permitting highly intuitive, single-handed control of multiple degrees of freedom, to and including, all six degrees of rotational and translational freedom without any inadvertent cross-coupling inputs.

28 Claims, 24 Drawing Sheets



Related U.S. Application Data

No. 15/071,624, filed on Mar. 16, 2016, now Pat. No. 9,547,380, which is a continuation of application No. 13/797,184, filed on Mar. 12, 2013, now abandoned.

(60) Provisional application No. 61/642,118, filed on May 3, 2012.

(51) **Int. Cl.**

A61B 34/30	(2016.01)
A61B 34/37	(2016.01)
G08C 19/16	(2006.01)
G06F 3/0338	(2013.01)
G06F 3/0346	(2013.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0338*** (2013.01); ***G08C 19/16*** (2013.01); *A61B 5/7475* (2013.01); *A61B 2560/0487* (2013.01); *G05B 2219/45123* (2013.01)

(58) **Field of Classification Search**
CPC A61B 2560/0487; G08C 19/16; G05B 2219/45123
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,216,467 A * 8/1980 Colston B25J 13/02 341/176
4,420,808 A * 12/1983 Diamond B64C 13/04 701/4
4,584,510 A * 4/1986 Hollow B64C 13/04 244/234
5,042,314 A * 8/1991 Rytter B62D 1/12 180/333
5,128,671 A * 7/1992 Thomas, Jr. A63F 13/06 244/191
5,223,776 A * 6/1993 Radke .... B25J 13/02 200/5 R
5,459,382 A 10/1995 Jacobus et al.
5,565,891 A * 10/1996 Armstrong G05G 9/04737 345/156
D375,765 S * 11/1996 Kawasaki D14/413
5,694,153 A * 12/1997 Aoyagi G05G 9/047 345/156
D389,198 S * 1/1998 Hama D14/413
5,749,577 A * 5/1998 Couch .... A63F 13/06 273/148 B
5,781,180 A * 7/1998 Couch .... A63F 13/06 273/148 B
5,831,408 A 11/1998 Jacobus et al.
5,963,196 A * 10/1999 Nishiumi A63F 13/02 345/161
H1822 H * 12/1999 Kelley 180/333
6,201,196 B1 * 3/2001 Wergen .... G05G 9/047 200/6 A
6,222,525 B1 * 4/2001 Armstrong G05G 9/04737 345/161
6,429,849 B1 * 8/2002 An G05G 9/047 345/161
6,459,420 B1 * 10/2002 Harris A63F 13/06 345/156
6,597,347 B1 * 7/2003 Yasutake G06F 3/0338 345/173
6,624,806 B2 * 9/2003 Hsu .... G05G 9/04788 273/148 B
6,865,342 B2 * 3/2005 Hirata G05G 9/047 348/211.7
7,131,389 B1 * 11/2006 Hawkes B63G 8/001 114/330
7,170,420 B2 * 1/2007 Phifer G08C 23/04 340/12.55
7,575,491 B1 * 8/2009 Martin B63H 21/213 440/6
7,793,890 B2 * 9/2010 Scherer A63H 30/04 244/189
7,823,685 B2 * 11/2010 Blind A01B 63/00 180/315
7,931,239 B2 * 4/2011 Pedersen B60V 1/06 244/189
8,089,225 B2 * 1/2012 Goossen G05D 1/0016 318/16
8,100,218 B2 * 1/2012 Case B62D 1/12 180/315
8,258,917 B2 * 9/2012 Cai G06F 3/0346 180/167
8,300,012 B2 * 10/2012 Yamamoto G06F 3/0346 345/158
8,344,914 B2 * 1/2013 Yeh G05G 9/047 341/20
8,371,187 B2 2/2013 Payandeh et al.
8,380,402 B2 * 2/2013 Hobenshield G05G 9/04785 701/50
D678,281 S * 3/2013 Yung D14/401
8,576,168 B2 * 11/2013 Kabasawa G06F 3/0346 345/157
8,716,973 B1 * 5/2014 Lammertse G06F 3/016 318/560
8,866,597 B2 * 10/2014 Brendel G08C 17/02 340/12.5
9,547,380 B2 1/2017 Parazynski
10,198,086 B2 2/2019 Parazynski et al.
2003/0006956 A1 * 1/2003 Wu G06F 3/0233 345/156
2003/0214484 A1 * 11/2003 Haywood G06F 3/0338 345/163
2005/0104742 A1 * 5/2005 Phifer G08C 23/04 340/12.55
2005/0277470 A1 * 12/2005 Watanachote A63F 13/06 463/37
2006/0137931 A1 6/2006 Berg et al.
2006/0164383 A1 * 7/2006 Machin G05G 9/047 345/156
2006/0262000 A1 * 11/2006 Strong G08C 17/00 341/176
2007/0080934 A1 * 4/2007 Chen G06F 3/0383 345/156
2008/0063400 A1 * 3/2008 Hudson A63H 30/04 398/106
2008/0132334 A1 * 6/2008 Nonaka A63F 13/10 463/37
2008/0174550 A1 * 7/2008 Laurila A63F 13/02 345/158
2009/0152782 A1 6/2009 Larson et al.
2009/0179869 A1 * 7/2009 Slotznick G06F 3/0202 345/173
2009/0213073 A1 8/2009 Obermeyer et al.
2010/0097309 A1 * 4/2010 Nishida G06F 3/0346 345/156
2010/0302017 A1 * 12/2010 Guglielmo G05G 9/047 340/407.2
2011/0148667 A1 * 6/2011 Yeh G05G 9/047 341/20
2011/0213384 A1 * 9/2011 Jeong A61B 34/30 606/130
2011/0219899 A1 9/2011 Dize et al.
2012/0187238 A1 * 7/2012 Lam A63H 27/12 244/17.21
2012/0249455 A1 10/2012 Nagata et al.
2013/0147611 A1 * 6/2013 Brendel G08C 17/02 340/12.5
2013/0293362 A1 11/2013 Parazynski
2016/0195939 A1 7/2016 Parazynski
2016/0241767 A1 8/2016 Cho et al.
2017/0121000 A1 5/2017 Forslund et al.
2017/0233983 A1 8/2017 Wright

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0246533 A1	8/2017	LaChappelle et al.	
2017/0269587 A1*	9/2017	Hong	B64C 39/024
2018/0164799 A1	6/2018	Hong	
2018/0356907 A1	12/2018	Parazynski et al.	
2019/0033987 A1	1/2019	Parazynski et al.	

OTHER PUBLICATIONS

Office Action for U.S. Appl. No. 13/797,184, dated Oct. 16, 2015, 15 pages.

Office Action for U.S. Appl. No. 15/071,624, dated May 17, 2016, 20 pages.

Office Action for U.S. Appl. No. 15/394,490, dated Nov. 21, 2018, 10 pages.

International Search Report and Written Opinion for International Application No. PCT/US2017/058905, dated Feb. 23, 2018, 5 pages.

Parazynski, Scott Edward, U.S. Appl. No. 15/964,064, Dynamically Balanced Multi-Degrees-Of-Freedom Hand Controller, filed Apr. 26, 2018, 85 pages.

Parazynski, Scott Edward, U.S. Appl. No. 15/796,744, Dynamically Balanced Multi-Degrees-Of-Freedom Hand Controller, filed Oct. 27, 2017, 64 pages.

Pamplona, V. F. et al., "The image-based data glove," Proceedings of the 10th Symposium on Virtual and Augmented Reality, (SVR'2008), Joao Pessoa, Brazil, 2008, 204-211.

Wilbert, J. et al., "Semi-robotic 6 degree of freedom positioning for intracranial high precision radiotherapy; first phantom and clinical results," Radiation Oncology, 5(42), 11 pages, May 26, 2010.

Zhai, X., "Human performance in six degree of freedom input control," Doctoral Dissertation University of Toronto, Graduate Department of Industrial Engineering, 179 pages, 1995.

"Feel Your Drone With MotionPilot's Haptic Joystick", Engadget, https://www.engadget.com/2018/01/19/motionpilothaptic-drone-joystick/, dated Jan. 19, 2018.

"CES 2018: TIE Develop World's First One-Hand Drone Controller System," Live At PC.com, https://liveatpc.com/ces-2018-tie-develops-worlds-first-one-hand-drone-controller-system/, dated Jan. 2018.

"[Review] JJRC H37 Baby Elfie: Is it a Worthy Successor?" DronesGlobe, http://www.dronesglobe.com/review/baby-elfie/, dated Oct. 7, 2017.

"Learn How to Pilot in Less Than 2 Minutes", Wepulsit, http://www.wepulsit.com/, dated 2017.

"InnovRC Firmware v1.2", InnovRC, http://www.innovrc.de/ivrcwiki/index.php?title=Hauptseite, dated Mar. 2013.

"H.E.A.R.T.—Hall Effect Accurate Technology: A Unique 3D Technological Innovation Built Into the New Thrustmaster Joystick," Thrustmaster, http://www.thrustmaster.com/press/heart-hall-effect-accurate-technology-unique-3d-technological-innovation-built-new-thrustmaste, dated Jan. 7, 2009.

* cited by examiner

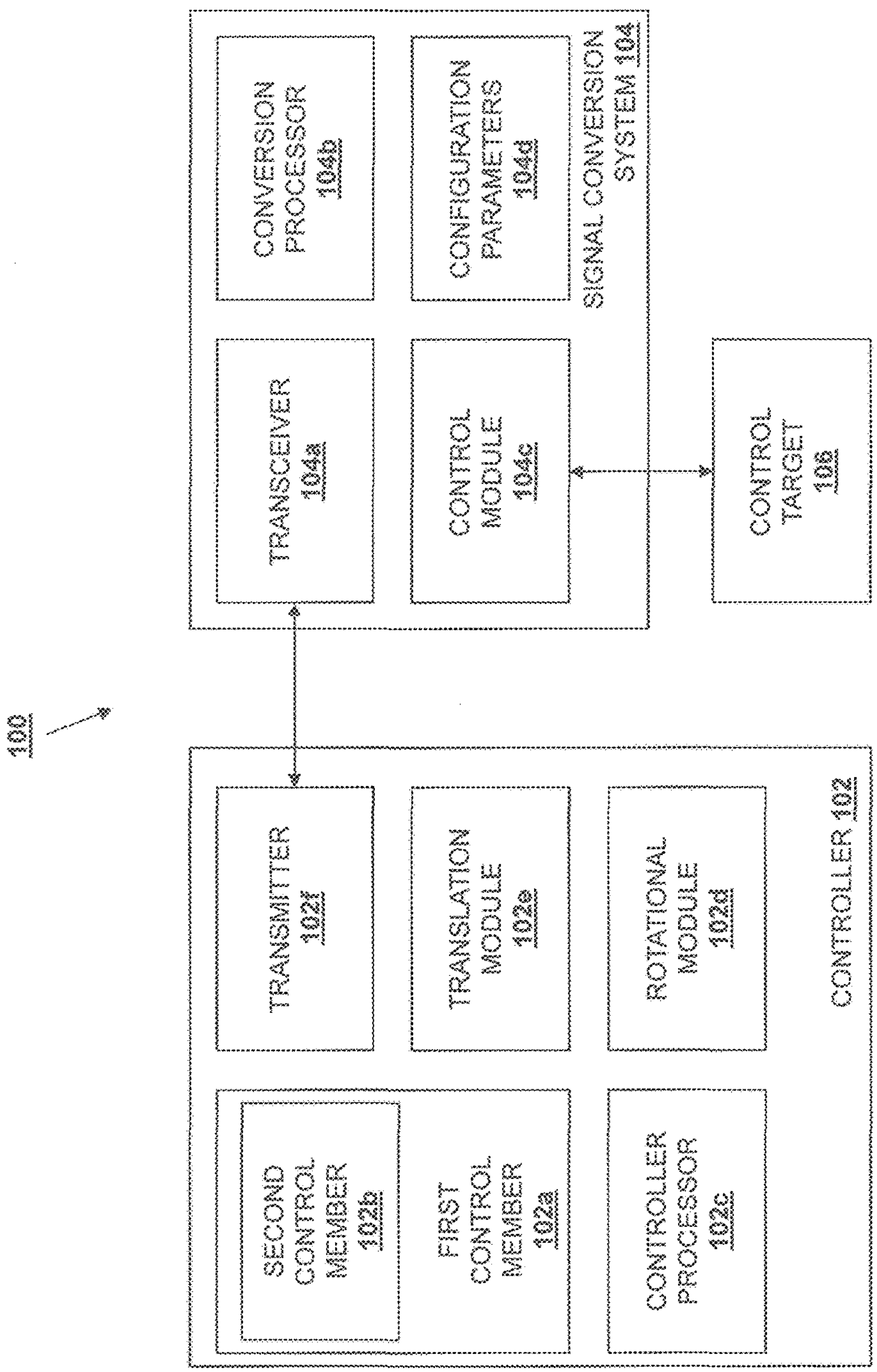

100
CONVERSION PROCESSOR 104b
CONFIGURATION PARAMETERS 104d
SIGNAL CONVERSION SYSTEM 104
TRANSCEIVER 104a
CONTROL MODULE 104c
CONTROL TARGET 106
TRANSMITTER 102f
TRANSLATION MODULE 102e
ROTATIONAL MODULE 102d
SECOND CONTROL MEMBER 102b
FIRST CONTROL MEMBER 102a
CONTROLLER PROCESSOR 102c
CONTROLLER 102

FIG. 1

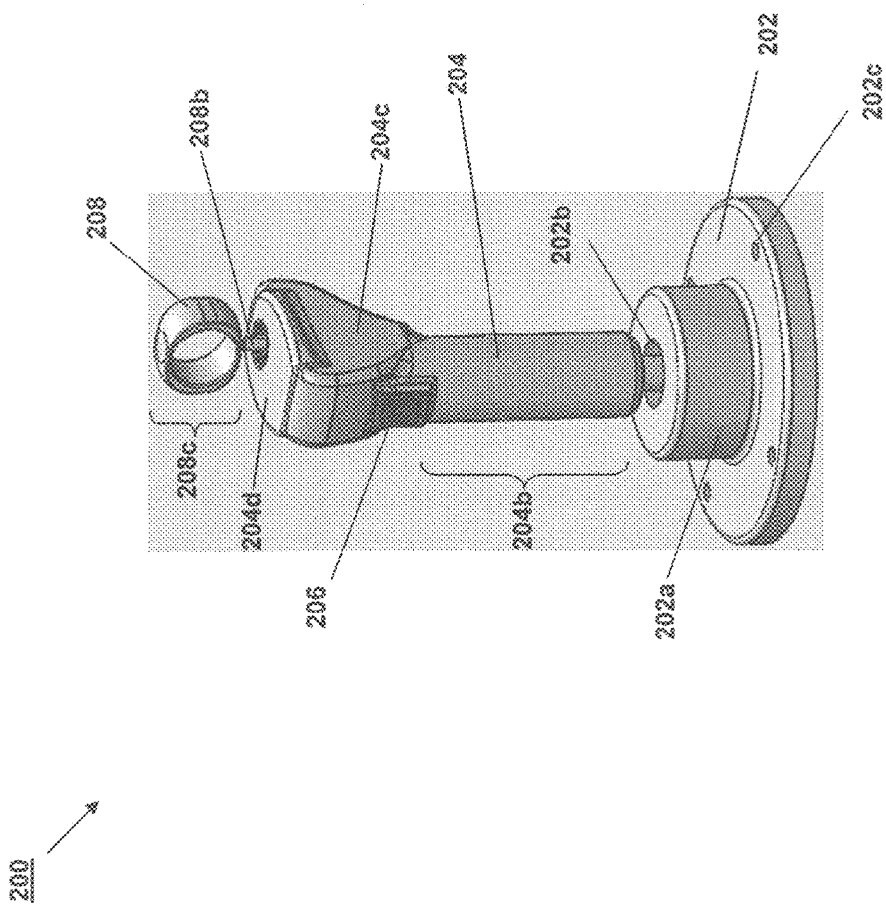


FIG. 2A

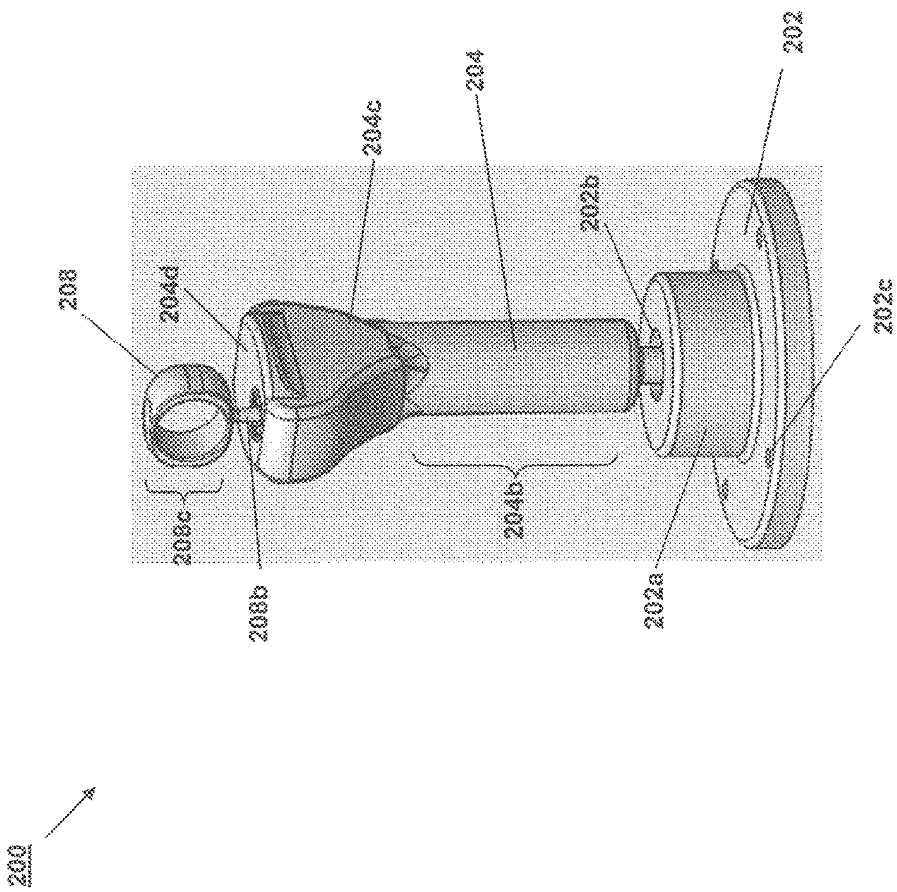


FIG. 2B

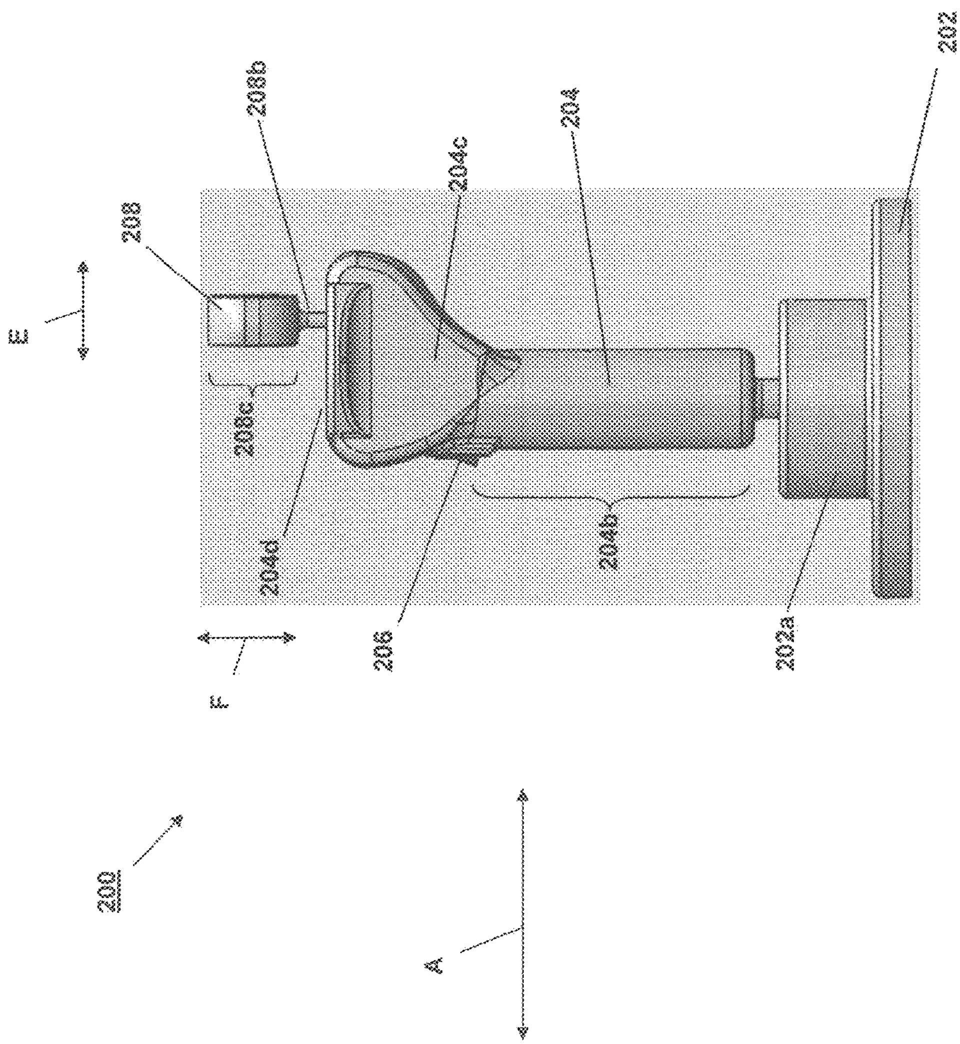


FIG. 2C

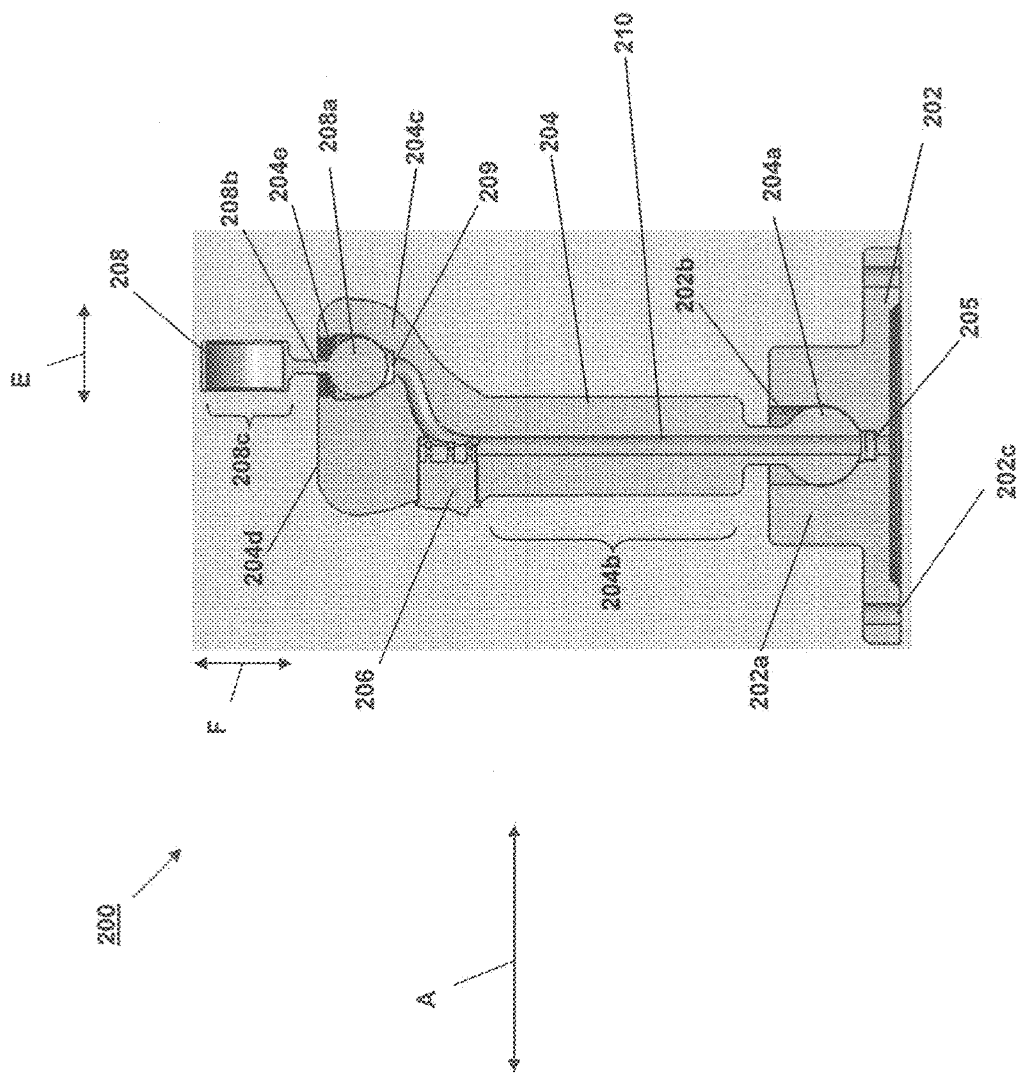

E
208
208b
204e
208a
204c
209
204
210
202b
204a
202
205
202c
208c
204d
204b
206
202a
F
200
A

FIG. 2D

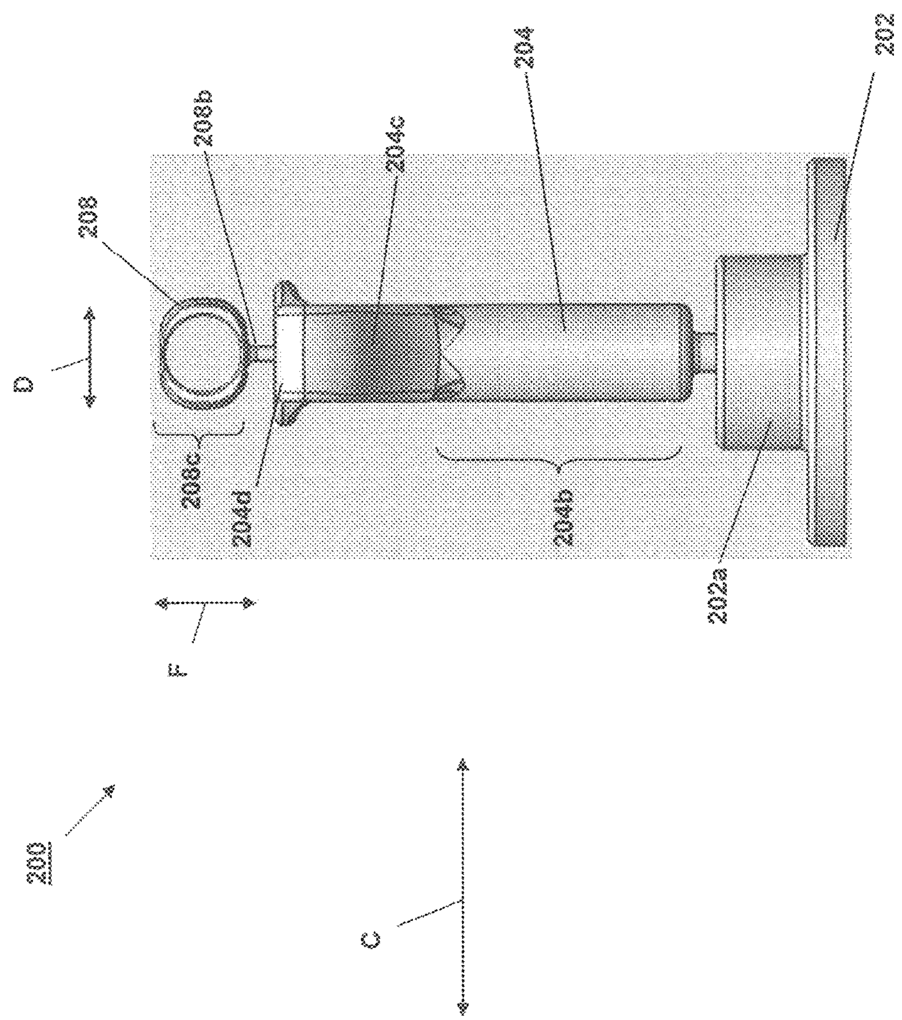


FIG. 2E

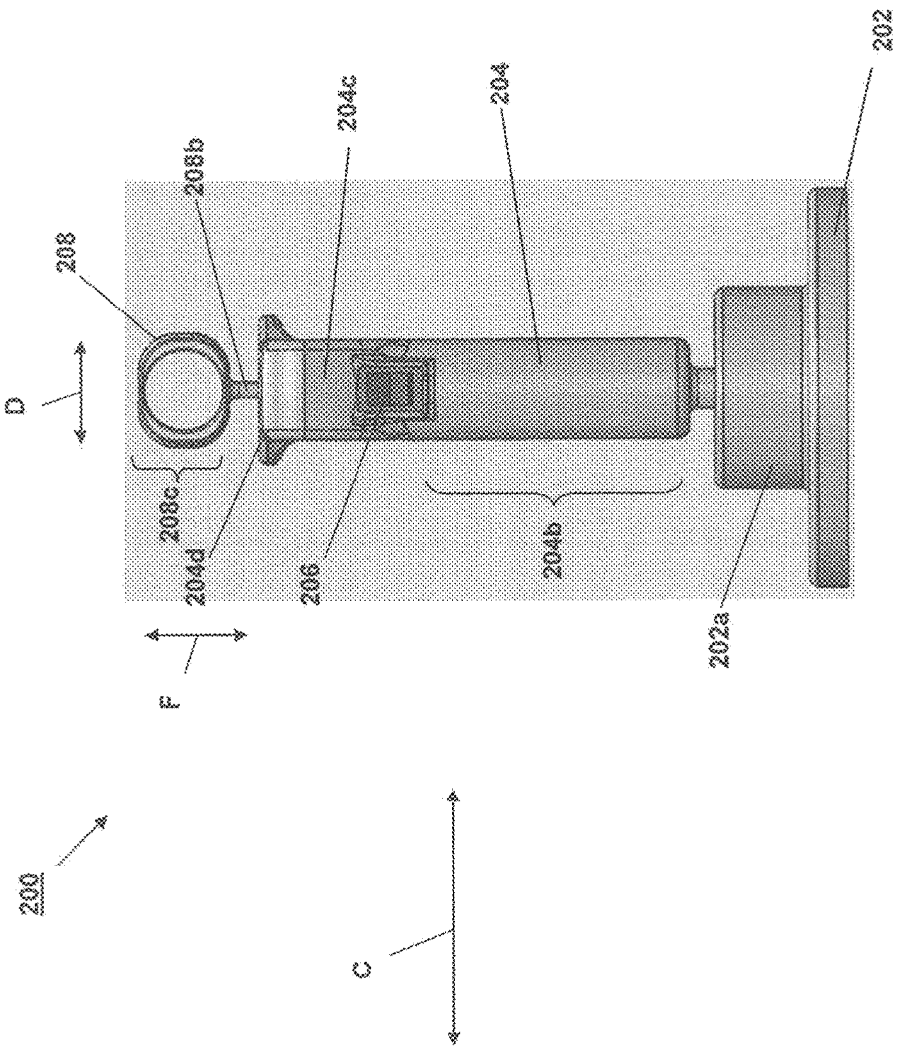


FIG. 2F

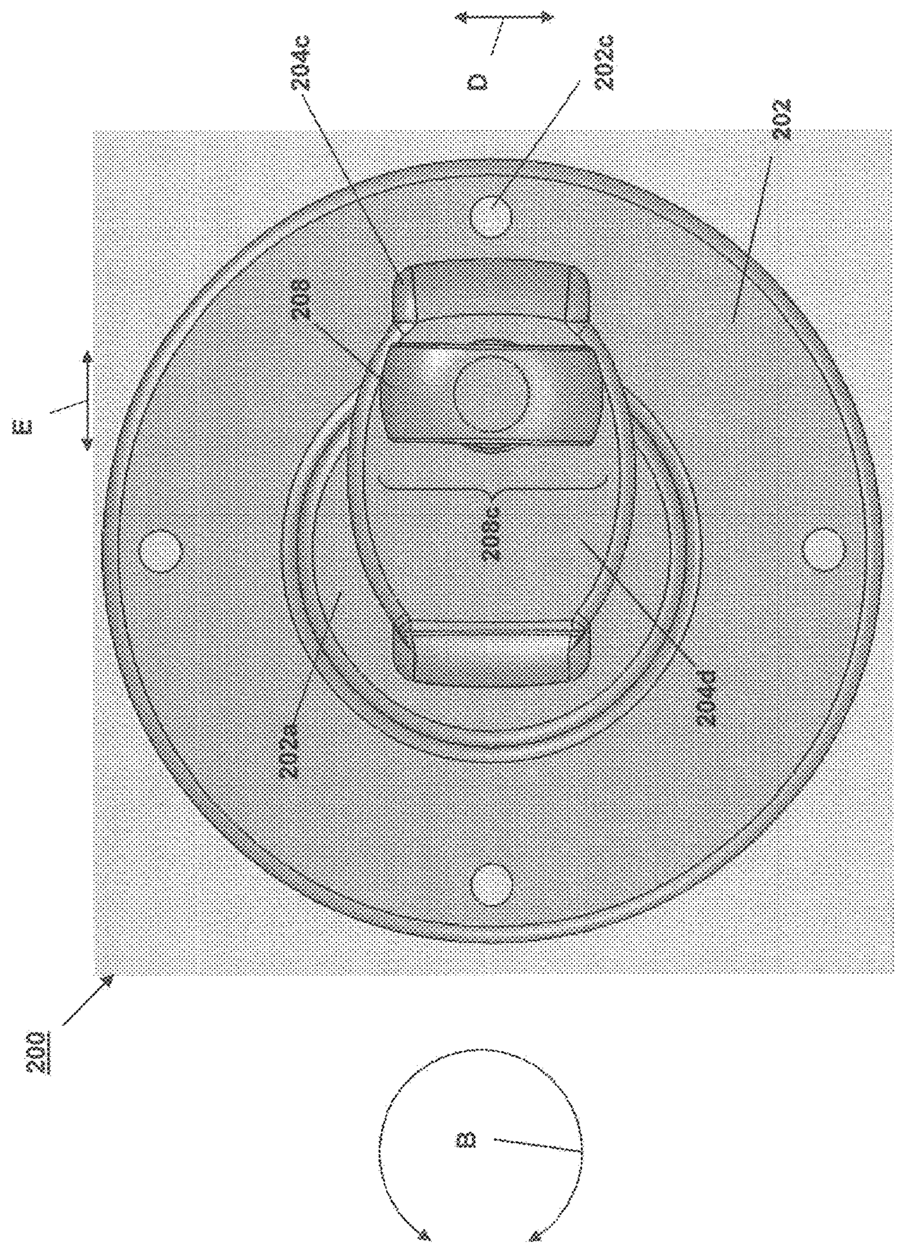


FIG. 2G

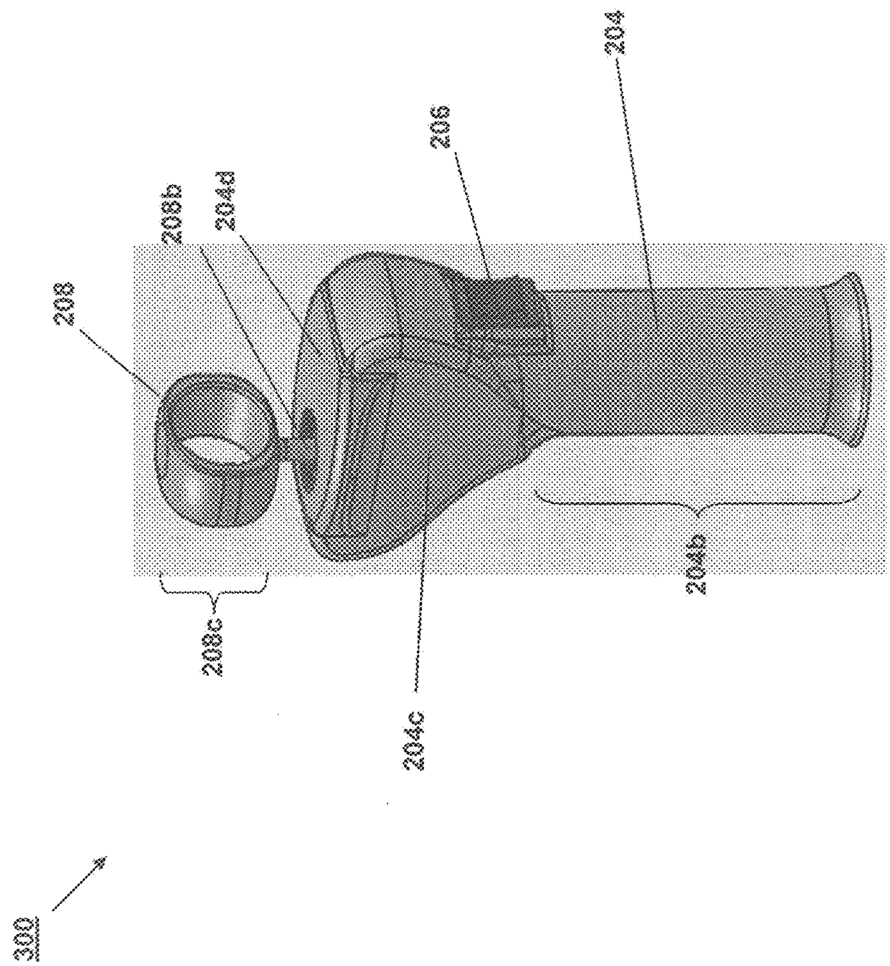


FIG. 3A

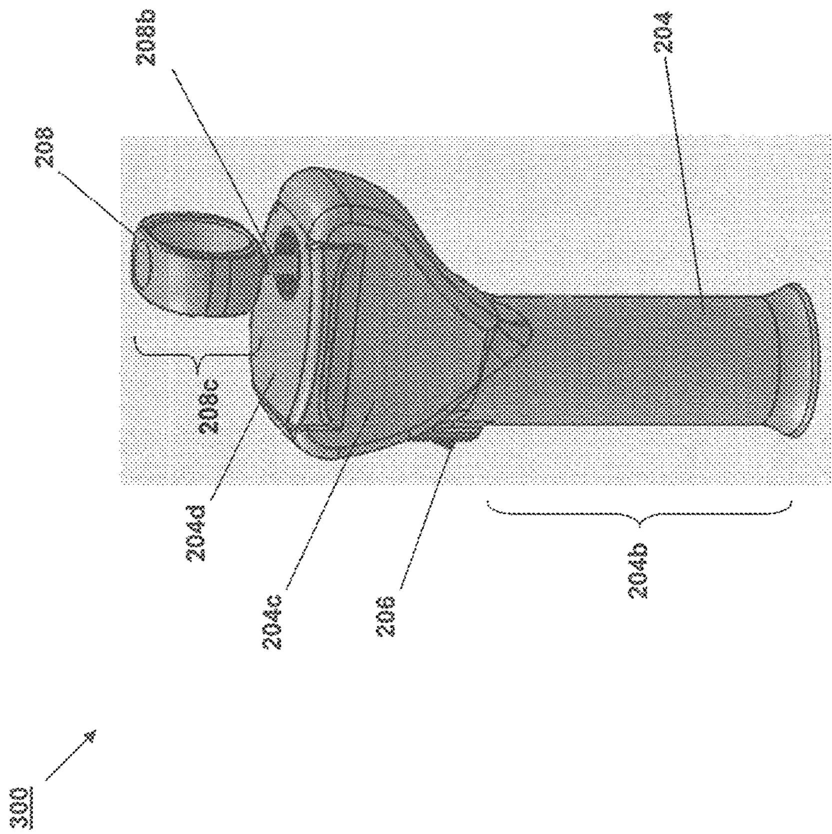


FIG. 3B

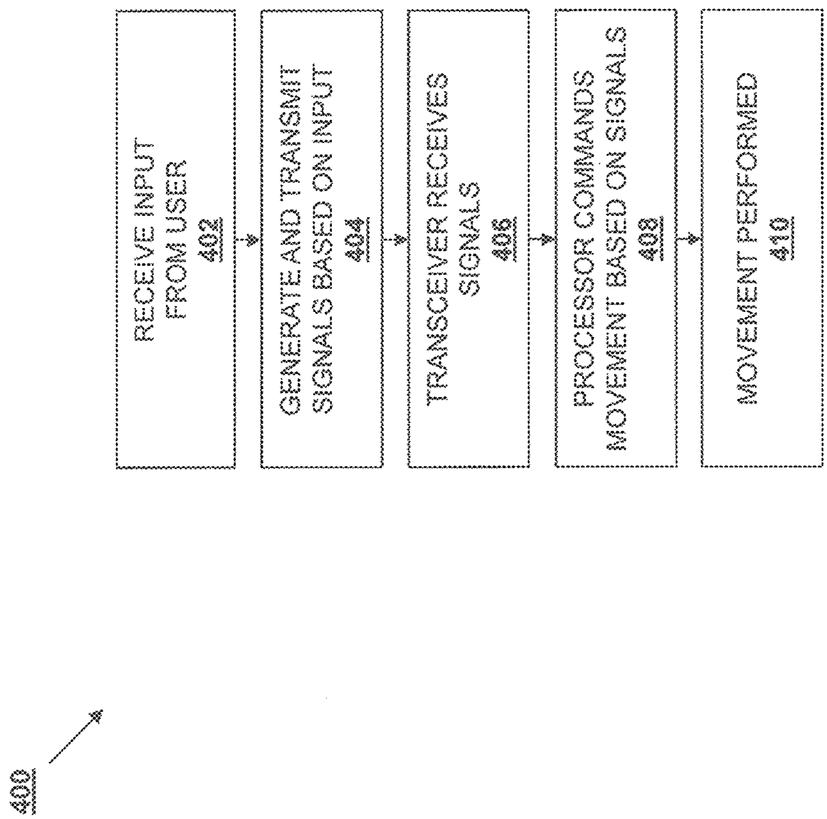

400
RECEIVE INPUT FROM USER
402
GENERATE AND TRANSMIT SIGNALS BASED ON INPUT
404
TRANSCEIVER RECEIVES SIGNALS
406
PROCESSOR COMMANDS MOVEMENT BASED ON SIGNALS
408
MOVEMENT PERFORMED
410

FIG. 4A

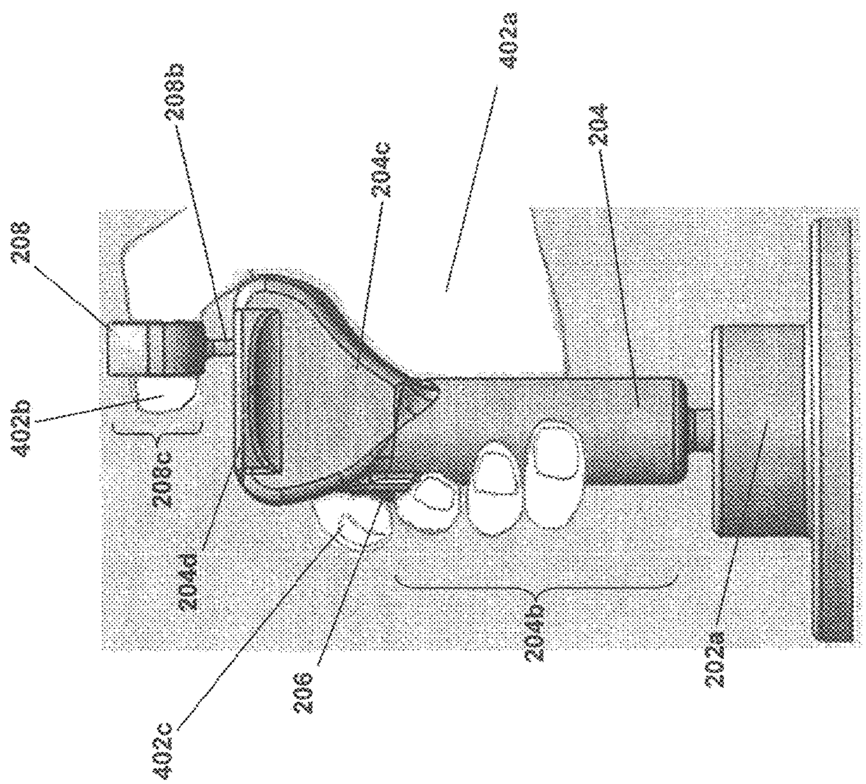


FIG. 4B

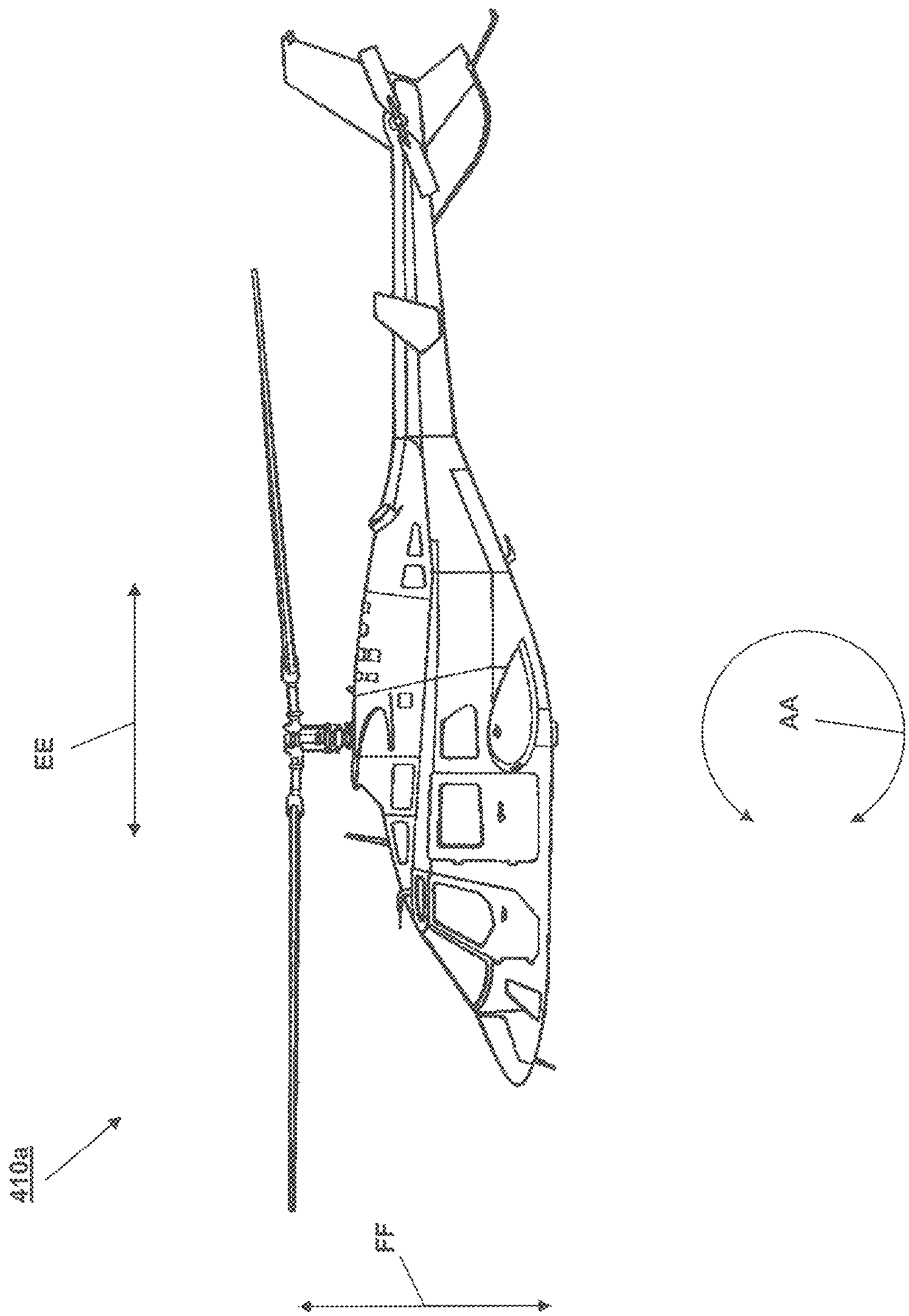


FIG. 4C

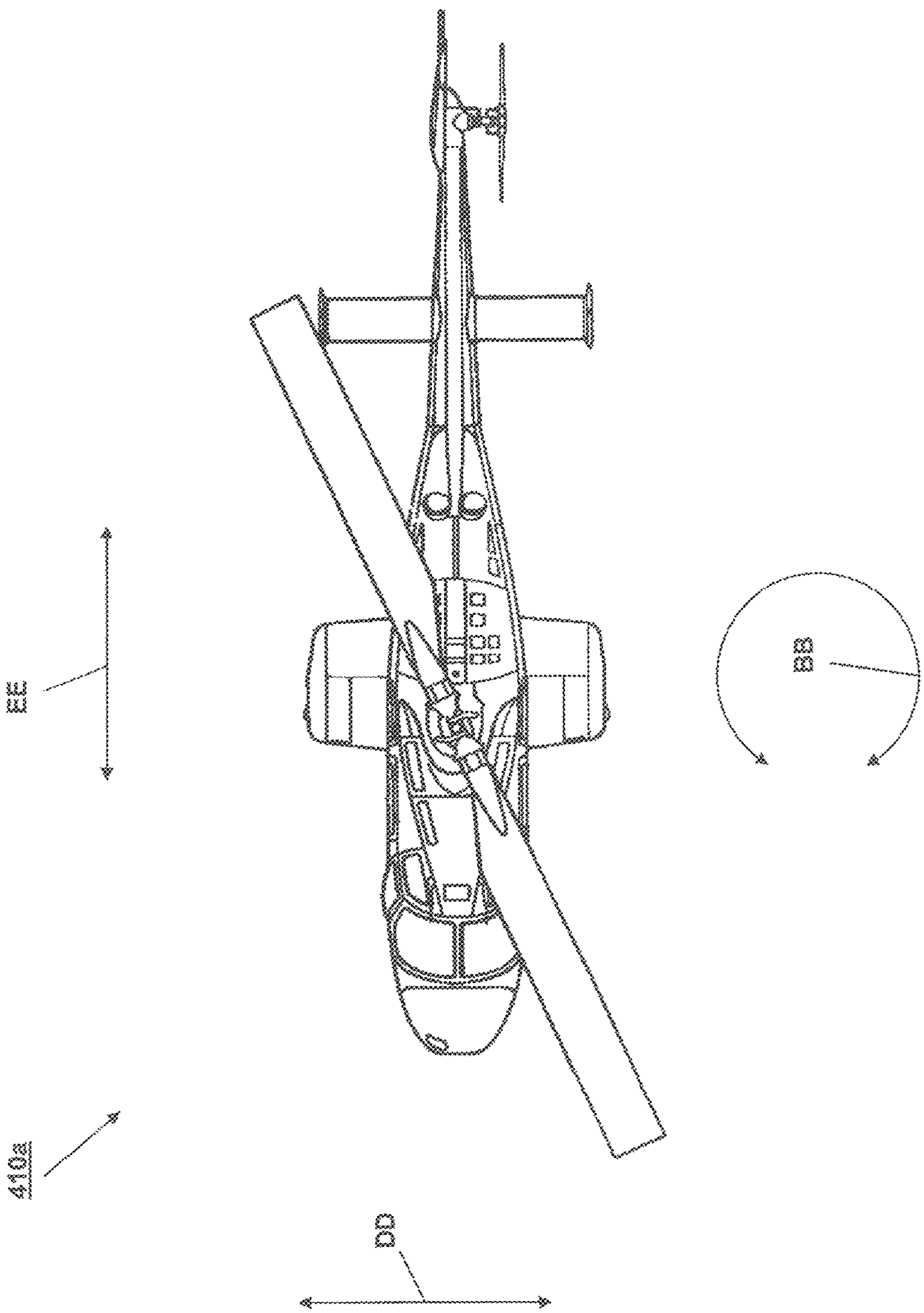


FIG. 4D

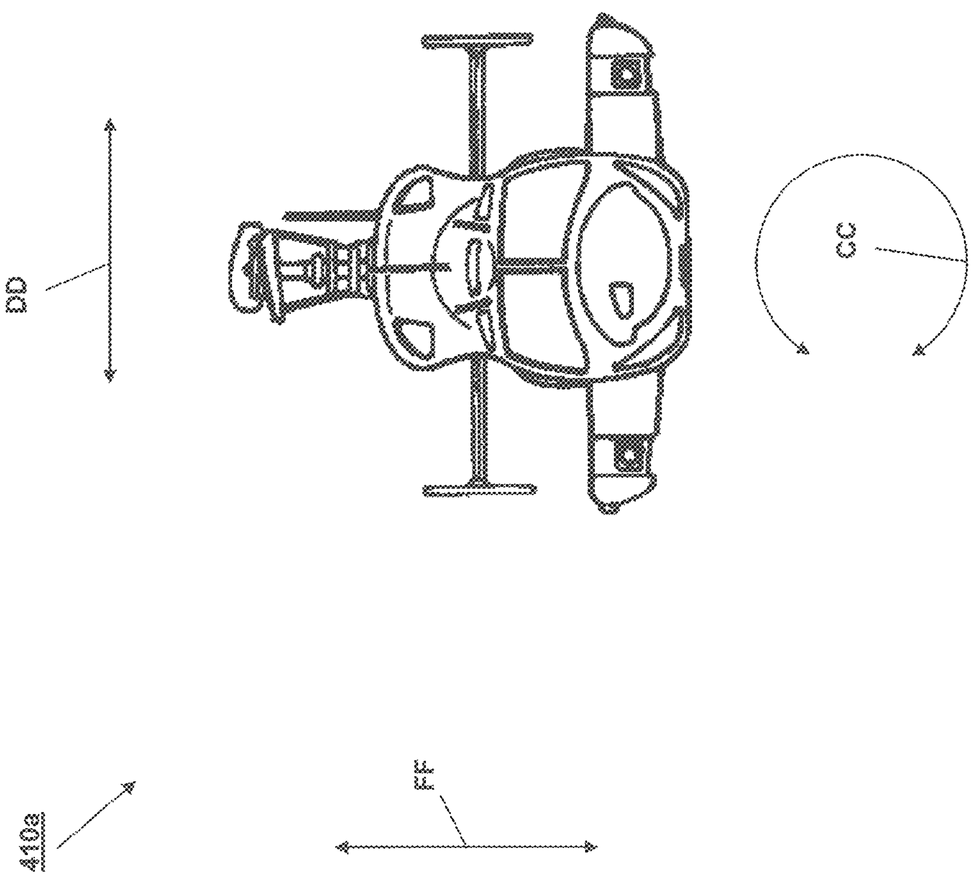


FIG. 4E

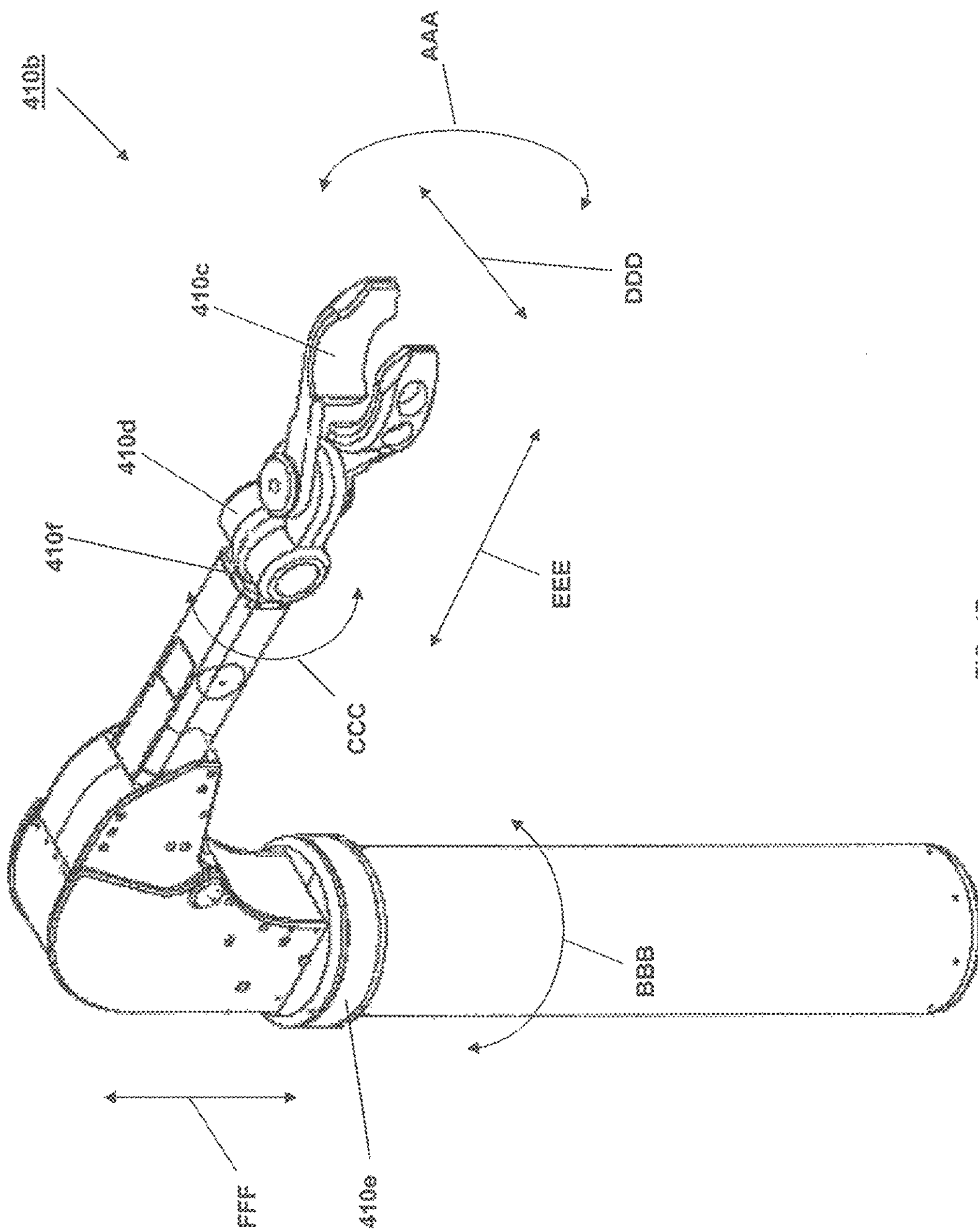


FIG. 4F

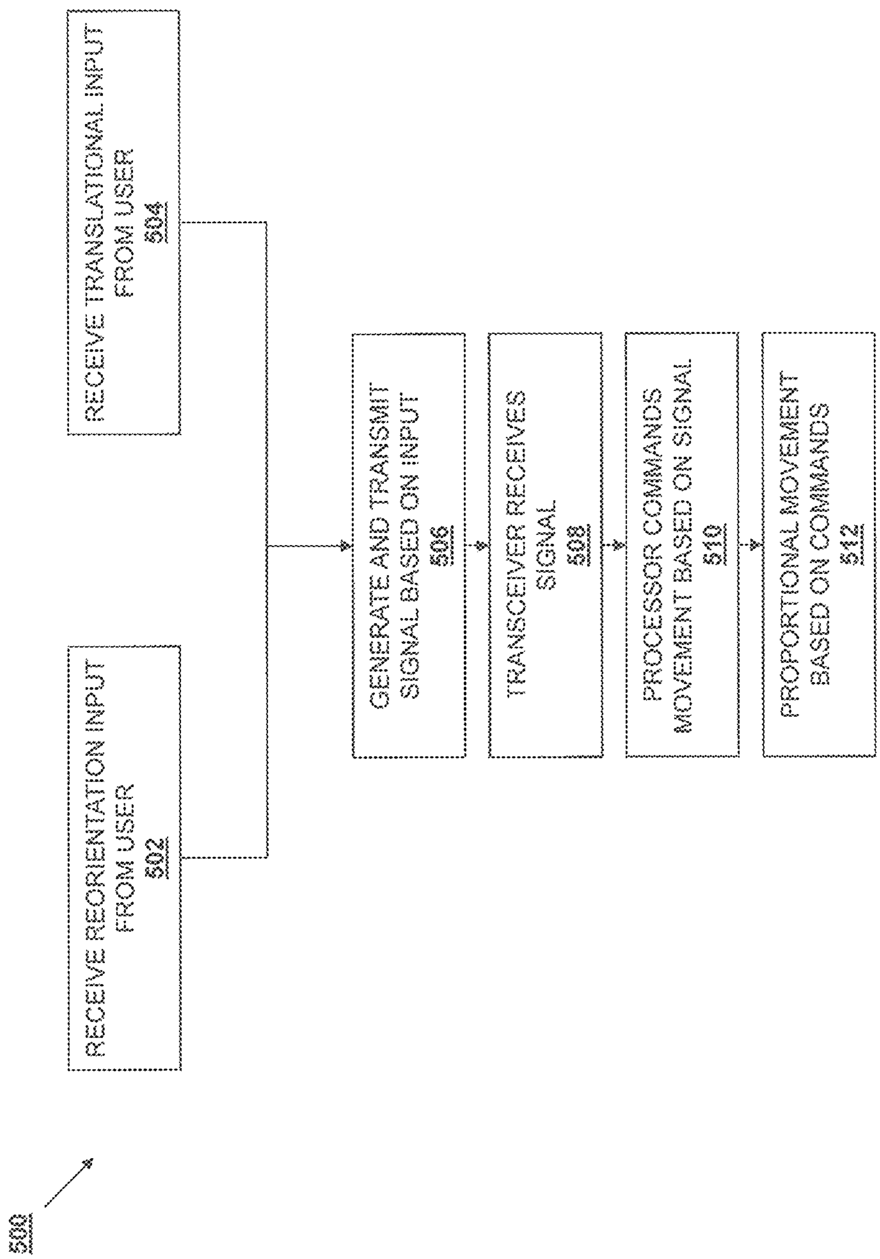

500
RECEIVE REORIENTATION INPUT FROM USER
502
RECEIVE TRANSLATIONAL INPUT FROM USER
504
GENERATE AND TRANSMIT SIGNAL BASED ON INPUT
506
TRANSCEIVER RECEIVES SIGNAL
508
PROCESSOR COMMANDS MOVEMENT BASED ON SIGNAL
510
PROPORTIONAL MOVEMENT BASED ON COMMANDS
512

FIG. 5

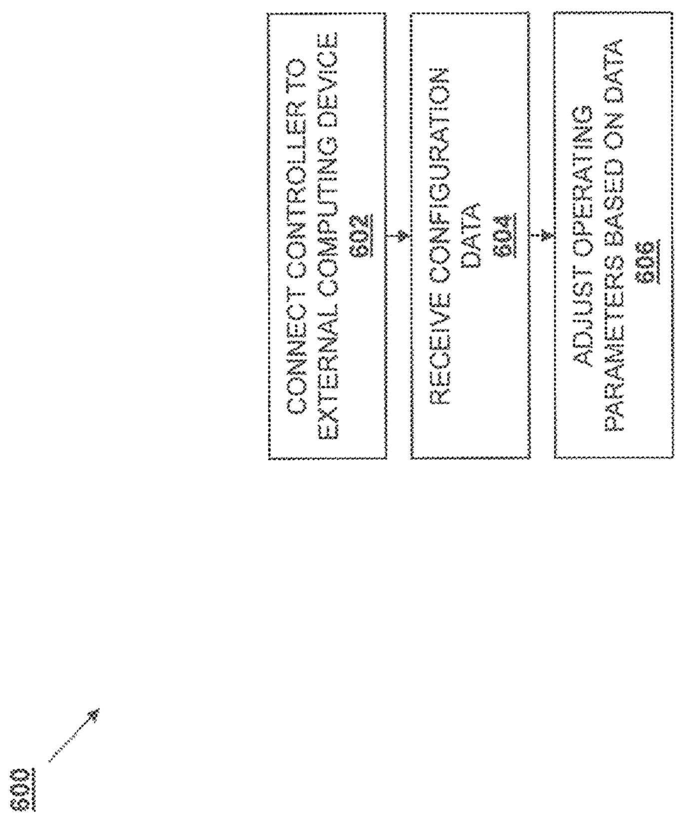

600
CONNECT CONTROLLER TO EXTERNAL COMPUTING DEVICE 602
RECEIVE CONFIGURATION DATA 604
ADJUST OPERATING PARAMETERS BASED ON DATA 606

FIG. 6

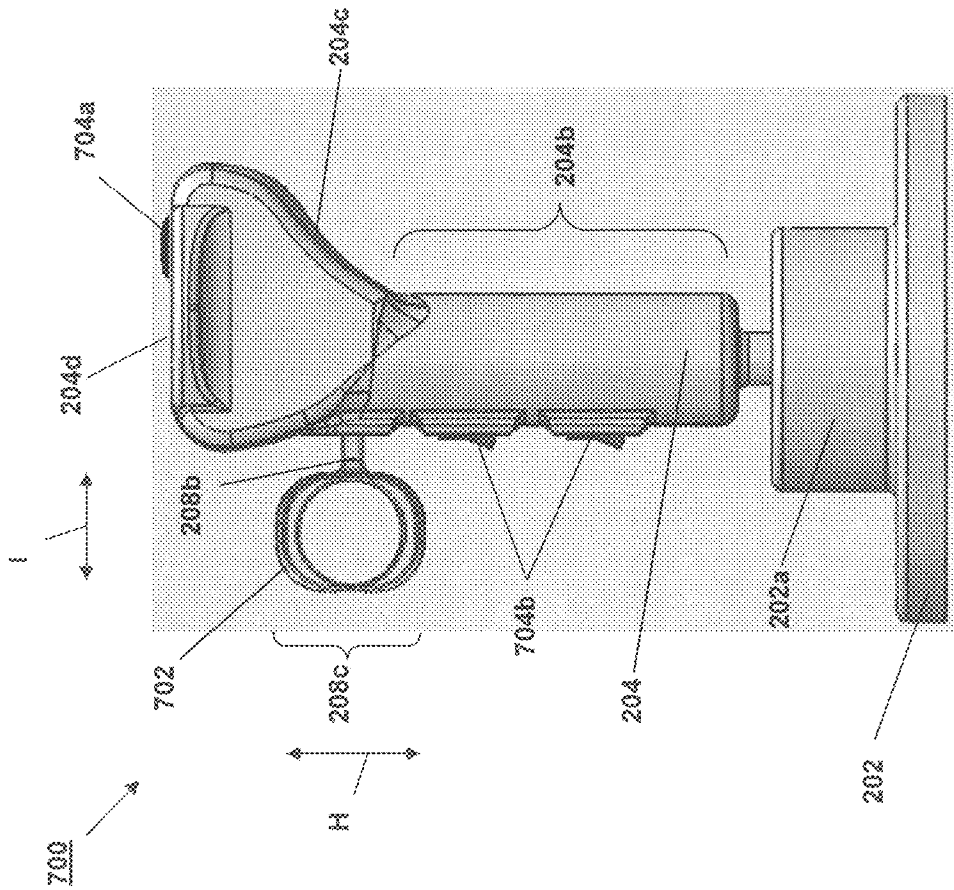


FIG. 7A

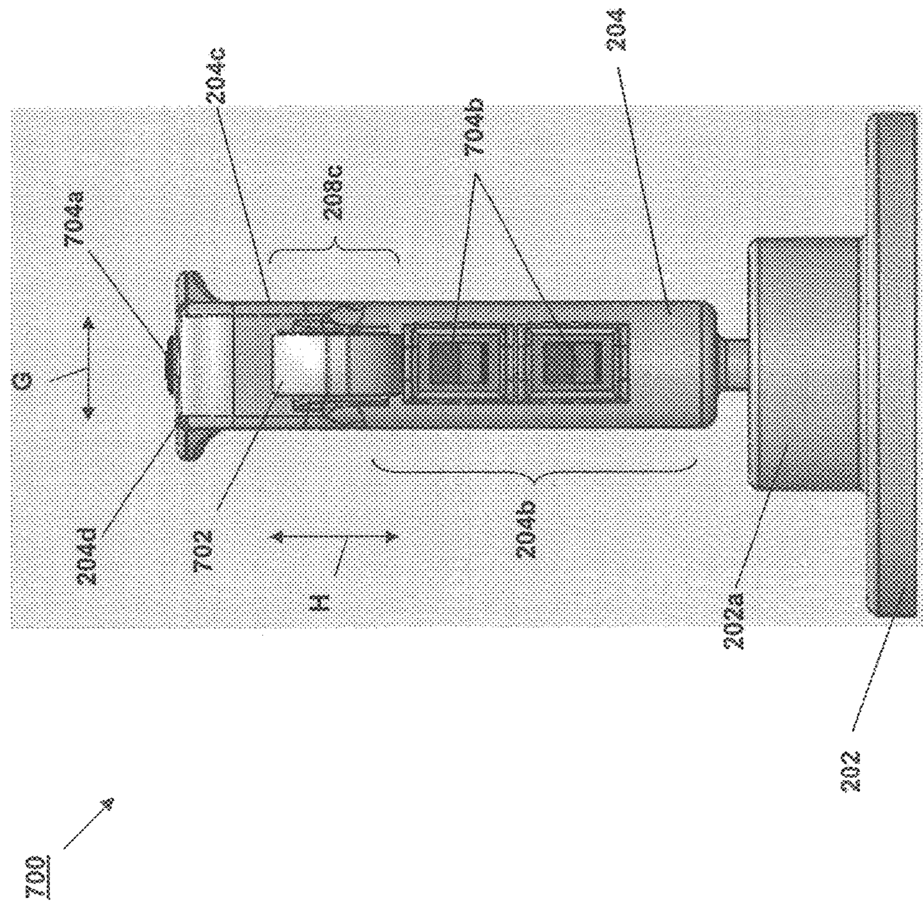


FIG. 7B

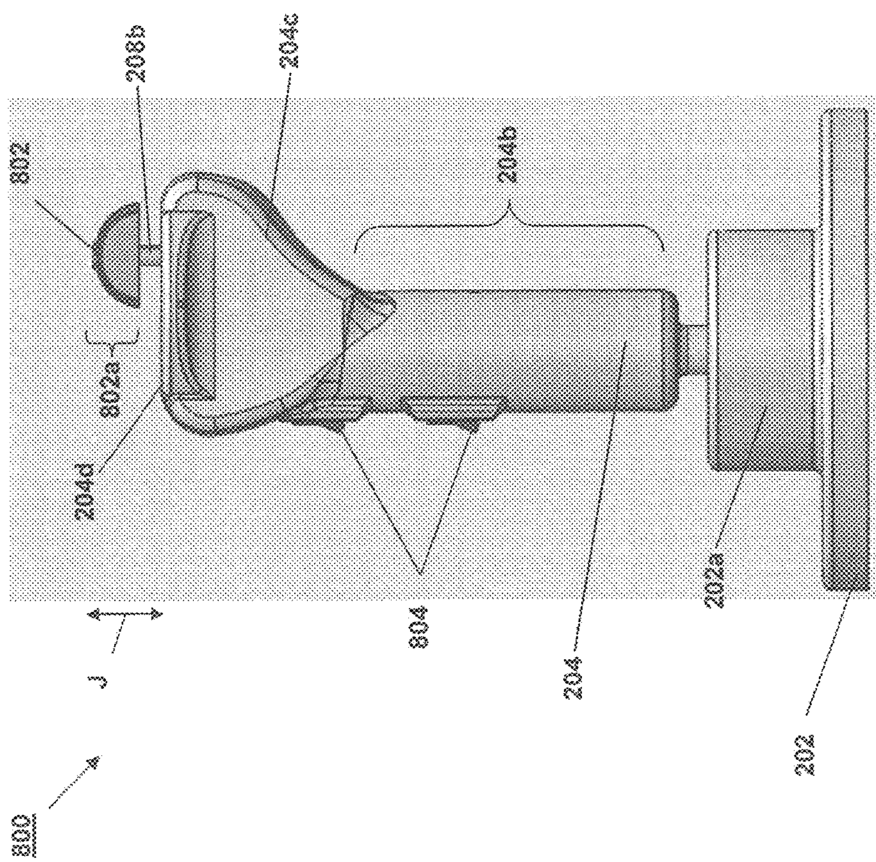


FIG. 8A

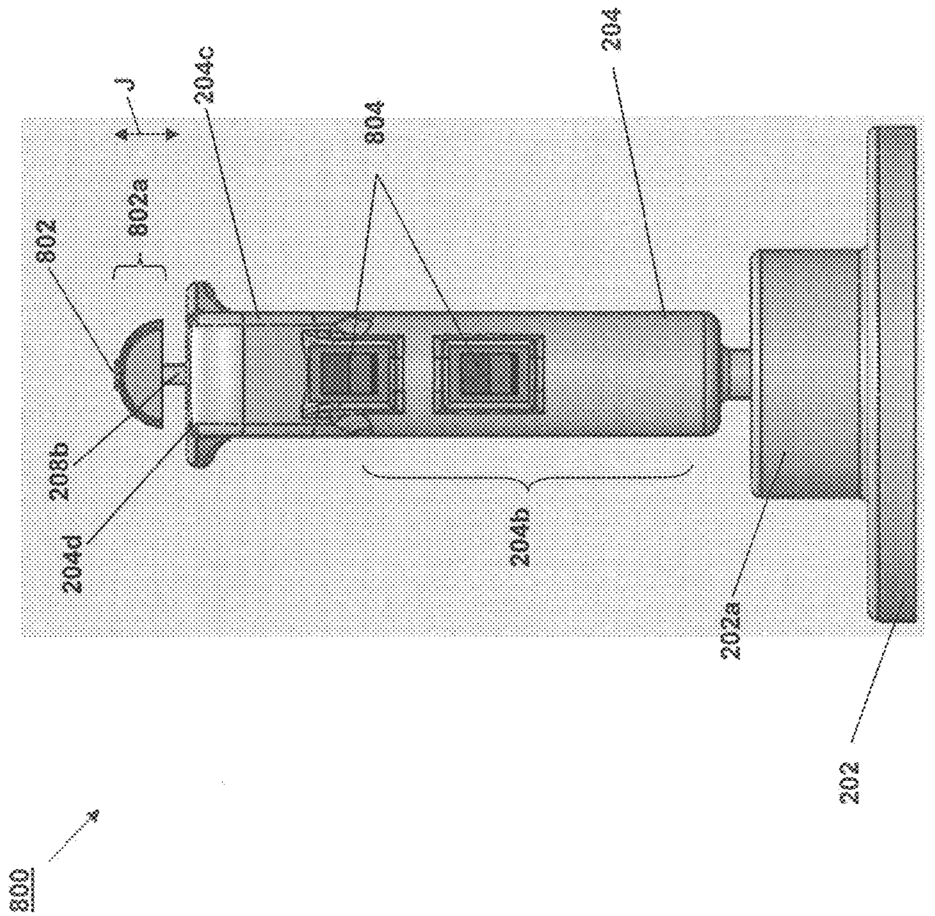


FIG. 8B

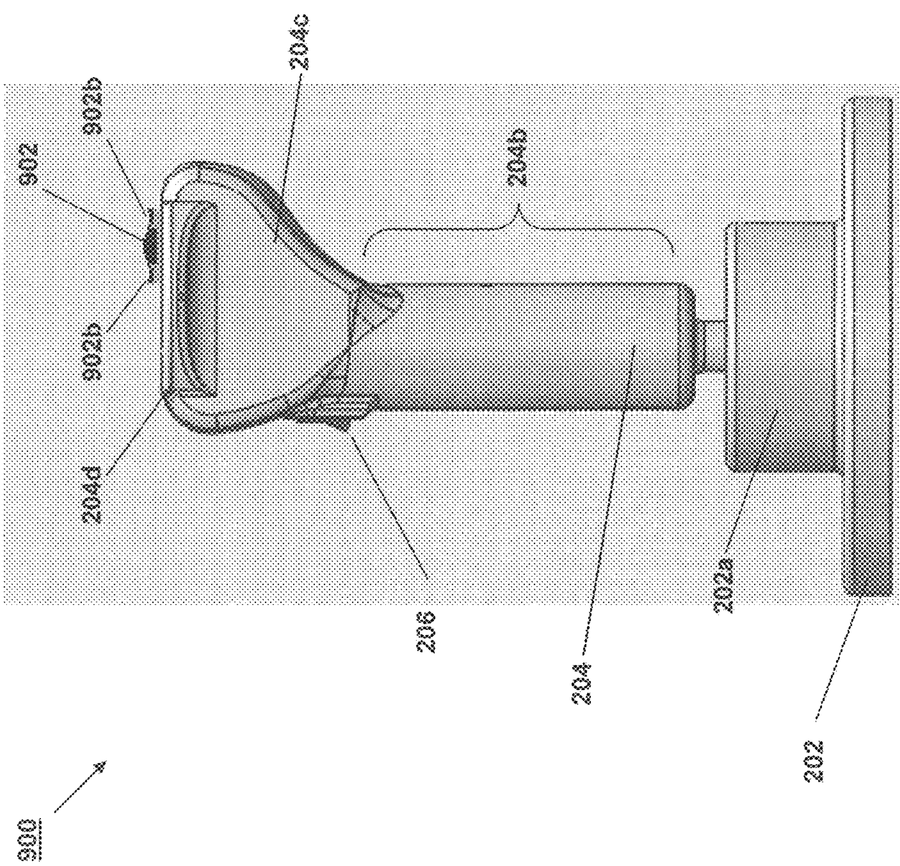


FIG. 9A

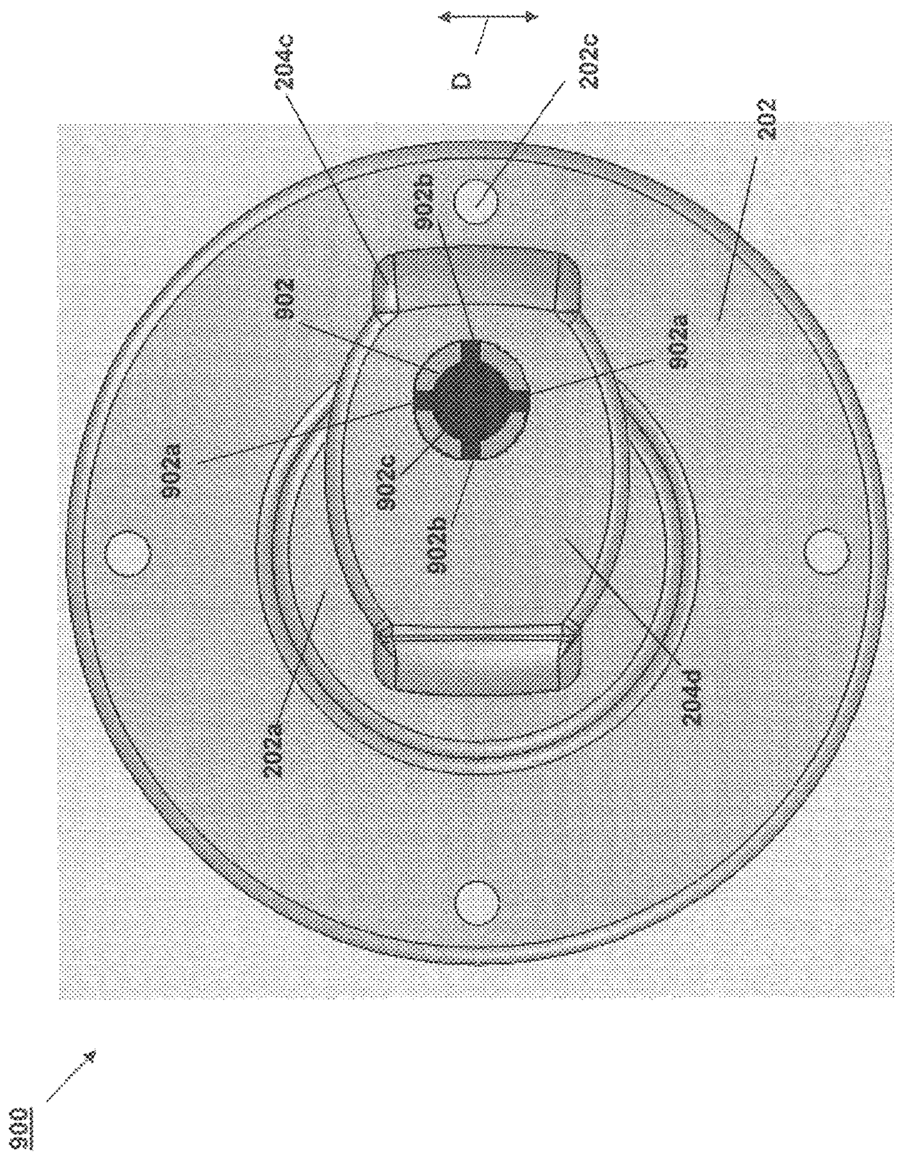


FIG. 9B

MULTI-DEGREES-OF-FREEDOM HAND CONTROLLER

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 15/394,490, entitled "Multi-Degrees-of-Freedom Hand Controller," filed Dec. 29, 2016, which is a continuation of U.S. patent application Ser. No. 15/071,624, entitled "Multi-Degrees-of-Freedom Hand Controller," filed Mar. 16, 2016, now U.S. Pat. No. 9,547,380, which is a continuation of U.S. patent application Ser. No. 13/797,184, entitled "Multi-Degrees-of-Freedom Hand Controller," filed Mar. 12, 2013, which claims priority to U.S. Provisional Pat. App. Ser. No. 61/642,118, entitled "Multi-Degrees-of-Freedom Hand Controller," filed May 3, 2012, the disclosure of each of which is specifically incorporated herein by express reference thereto.

BACKGROUND OF THE INVENTION

Field of the Invention

The present disclosure relates generally to control systems and more particularly to a controller that provides a user with the ability to send navigation signals for up to six independent degrees of freedom, without cross-coupling, using a controller that is operable with a single hand. In some embodiments, the controller is operable to decouple translational motion from attitude adjustment.

BRIEF SUMMARY OF THE INVENTION

A controller includes (a) a first control member, (b) a second control member extending from a portion of the first control member, and (c) a controller processor coupled to the first control member and the second control member, wherein the controller processor is operable to produce a rotational movement output signal in response to movement of the first control member, wherein the controller processor is operable to produce a translational movement output signal in response to movement of the second control member relative to the first control member. In an embodiment, the controller processor is operable to produce one or more of a pitch movement output signal in response to a first predetermined movement of the first control member, a yaw movement output signal in response to a second predetermined movement of the first control member, and a roll movement output signal in response to a third predetermined movement of the first control member. In an embodiment, the controller processor is operable to produce one or more of an x-axis movement output signal in response to a first predetermined movement of the second control member, a y-axis movement output signal in response to a second predetermined movement of the second control member, and a z-axis movement output signal in response to a third predetermined movement of the second control member. In an embodiment, the controller processor is operable to produce at least two different types of rotational movement output signals in response to movement of the first control member, and wherein the controller processor is operable to produce at least two different types of translational movement output signals in response to movement of the second control member relative to the first control member. Furthermore, in some embodiments, the controller processor is operable to produce output signals for movement in one degree of freedom to six degrees of freedom simultaneously (e.g., three rotational movement output signals and three translational movement output signals). In an embodiment, the controller processor is operable to produce at least three different types of rotational movement output signals in response to movement of the first control member, and wherein the controller processor is operable to produce at least three different types of translational movement output signals in response to movement of the second control member relative to the first control member. In an embodiment, the first control member is configured to be gripped and moved using a single hand, and wherein the second control member is configured to be moved using one or more digits on the single hand. In an embodiment, the one or more digits include the thumb. In an embodiment, the first control member is moveably coupled to a base, and wherein the controller processor is operable to produce the rotational movement output signal in response to movement of the first control member relative to the base. In an embodiment, the first control member comprises at least one motion sensor, and wherein the controller processor is operable to produce the rotational movement output signal in response to movement of the first control member in space that is detected by the at least one motion sensor. In an embodiment, a control button is located on the first control member. Furthermore, multi-function switches, trim control, and/or other functional switches and controls may be added to either of the first control member and/or the second control member.

A computer system includes (a) a processor, (b) a non-transitory, computer-readable medium coupled to the processor and including instruction that, when executed by the processor, cause the processor to provide a control program, and (c) a user input device coupled to the processor, the user input device comprising: (i) a first control member, wherein movement of the first control member causes the processor to provide one of a plurality of rotational movement instructions in the control program, and (ii) a second control member extending from a portion of the first control member, wherein movement of the second control member causes the processor to provide one of a plurality of translational movement instructions in the control program. In an embodiment, a first predetermined movement of the first control member causes the processor to provide a pitch movement instruction in the control program, a second predetermined movement of the first control member causes the processor to provide a yaw movement instruction in the control program, and a third predetermined movement of the first control member cause the processor to provide a roll movement instruction in the control program. In an embodiment, a first predetermined movement of the second control member causes the processor to provide an x-axis movement instruction in the control program, a second predetermined movement of the second control member causes the processor to provide a y-axis movement instruction in the control program, and a third predetermined movement of the second control member causes the processor to provide a z-axis movement instruction in the control program. In an embodiment, the first control member is configured to be gripped and moved using a single hand, and wherein the second control member is configured to be moved using one or more digits on the single hand. In an embodiment, the one or more digits includes the thumb. In an embodiment, the first control member is moveably coupled to a base, and wherein movement of the first control member relative to the base causes the processor to provide the one of a plurality of rotational movement instructions in the control program. In an embodiment, the first control member comprises at least one motion sensor, and wherein movement of the first control member in space that is detected by the at least one motion sensor causes the processor to provide the one of a plurality of translational movement instructions in the control program.

A control method includes: (a) providing a controller including a first control member and a second control member extending from a portion of the first control member, (b) sending a rotational movement output signal in response to moving the first control member, and (c) sending a translational movement output signal in response to moving the second control member relative to the first control member. In an embodiment, the sending the rotational movement output signal in response to moving the first control member includes sending a pitch movement output signal in response to a first predetermined movement of the first control member, sending a yaw movement output signal in response to a second predetermined movement of the first control member, and sending a roll movement output signal in response to a third predetermined movement of the first control member. In an embodiment, the sending the translational movement output signal in response to moving the second control member relative to the first control member includes sending an x-axis movement output signal in response to a first predetermined movement of the second control member, sending a y-axis movement output signal in response to a second predetermined movement of the second control member, and sending a z-axis movement output signal in response to a third predetermined movement of the second control member. In an embodiment, the moving the first control member includes gripping and moving the first control member using a single hand, and wherein the moving the second control member relative to the first control member includes moving the second control member using a thumb on the single hand. In an embodiment, the sending the rotational movement output signal in response to moving the first control member includes detecting the movement of the first control member about a moveable coupling on a base. In an embodiment, the sending the rotational movement output signal in response to moving the first control member includes detecting the movement of the first control member in space using at least one motion sensor.

A method for performing a medical procedure includes controlling one or more medical instruments using the controller described above. In an embodiment, the medical procedure includes one or more of laparoscopic surgery, natural orifice surgery, minimally-invasive surgery, prenatal surgery, intrauterine surgery, microscopic surgery, interventional radiology, interventional cardiology, endoscopy, cystoscopy, bronchoscopy, and colonoscopy. In an embodiment, the medical procedure utilizes one or more of Hansen robotic control, Da Vinci robotic control, three dimensional image guidance, and four dimensional image guidance.

A method for controlling a vehicle includes controlling one or more vehicle subsystems using the controller described above. In an embodiment, the vehicle includes one or more of an unmanned aerial vehicle, an unmanned submersible vehicle, a heavy mechanized vehicle, a piloted aircraft, a helicopter, a spacecraft, a spacecraft docking system, and a general aviation system.

A method for controlling a military system includes controlling one or more military subsystems using the controller described above. In an embodiment, the military system includes one or more of a weapons-targeting system, counter-improvised-explosive-device system, an air-to-air refueling system, and an explosives handling system.

A method for controlling an industrial system includes controlling one or more industrial subsystems using the controller described above. In an embodiment, the industrial system includes one or more of an oil exploration system, an overhead crane, a cherry picker, a boom lift, a basket crane, an industrial lift, a firefighting system, a dangerous materials handling system (including, without limitation, nuclear or biological materials handling systems), a metallurgical handling or foundry system, a steel or metals manufacturing system, a high-temperature handling or processing system, an explosives or ordinance handling system, and a waste management system.

A method for controlling a consumer device system includes controlling one or more consumer device subsystems using the controller described above. In an embodiment, the consumer device system includes one or more of a consumer electronics device, a video game console, a three-dimensional computer navigation system, a radio-controlled vehicle, and a three-dimensional computer-aided drafting system.

BRIEF DESCRIPTION OF THE DRAWINGS

For promoting an understanding of the principles of the invention, reference will now be made to the embodiments, or examples, 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 invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one of ordinary skill in the art to which the invention relates.

The following drawings form part of the present specification and are included to demonstrate certain aspects of the present invention. The invention may be better understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

FIG. **1** is a schematic view of an embodiment of a control system.

FIG. **2**A is a front-perspective view illustrating an embodiment of a controller;

FIG. **2**B is a rear-perspective view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **2**C is a side view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **20** is a cross-sectional view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **2**E is a rear view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **2**F is a front view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **2**G is a top view illustrating an embodiment of the controller of FIG. **2**A;

FIG. **3**A is a front-perspective view illustrating an embodiment of a controller;

FIG. **3**B is a side-perspective view illustrating an embodiment of the controller of FIG. **3**A;

FIG. **4**A is a flowchart illustrating an embodiment of a method for controlling a control target;

FIG. **4**B is a side view illustrating an embodiment of a user using the controller depicted in FIG. **2**A-FIG. **2**G with a single hand;

FIG. **4**C is a side view illustrating an embodiment of a physical or virtual vehicle control target executing movements according to the method of FIG. **4**A;

FIG. **4**D is a top view illustrating an embodiment of the physical or virtual vehicle control target of FIG. **4**C executing movements according to the method of FIG. **4**A;

FIG. **4**E is a front view illustrating an embodiment of the physical or virtual vehicle control target of FIG. **4**C executing movements according to the method of FIG. **4**A;

FIG. **4**F is a perspective view illustrating an embodiment of a tool control target executing movements according to the method of FIG. **4**A;

FIG. **5** is a flowchart illustrating an embodiment of a method for controlling a control target;

FIG. **6** is a flowchart illustrating an embodiment of a method for configuring a controller;

FIG. **7**A is a side view illustrating an embodiment of a controller;

FIG. **7**B is a front view illustrating an embodiment of the controller of FIG. **7**A;

FIG. **8**A is a side view illustrating an embodiment of a controller;

FIG. **8**B is a front view illustrating an embodiment of the controller of FIG. **8**A;

FIG. **9**A is a side view illustrating an embodiment of a controller; and

FIG. **9**B is a top view illustrating an embodiment of the controller of FIG. **8**A.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

In the drawings and description that follows, the drawings are not necessarily to scale. Certain features of the invention may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. The present disclosure is susceptible to embodiments of different forms. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that illustrated and described herein. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce desired results. The various characteristics mentioned above, as well as other features and characteristics described in more detail below, will be readily apparent to those skilled in the art upon reading the following description of illustrative embodiments of the invention, and by referring to the drawings that accompany the specification.

Conventionally, multiple discrete controllers are utilized to allow a user to control a control target having more than three degrees of freedom. Furthermore, multiple discrete controllers have been required for any conventional control system that controls a control target having six degrees of freedom. For example, a set of independent controllers (e.g., joysticks, control columns, cyclic sticks, foot pedals, and/or other independent controllers as may be known by one or more of ordinary skill in the art) may be provided to receive a variety of different rotational parameters (e.g., pitch, yaw, and roll) from a user for a control target (e.g., an aircraft, submersible vehicles, spacecraft, a control target in a virtual environment, and/or a variety of other control targets as may be known by one or more of ordinary skill in the art), while a set of independent controllers may be provided to control other navigational parameters such as translation (e.g., x-, y-, and z-axis movement) in a three-dimensional (3D) space, velocity, acceleration, and/or a variety of other navigational parameters as may be known by one or more of ordinary skill in the art.

The present disclosure describes several embodiments of a control system that allows a user to control a control target in six DOF (6-DOF) using a single controller. In one embodiment, a unified hand controller may include a first control member for receiving rotational inputs (e.g., pitch, yaw, and roll) and a second control member that extends from the first control member and that is for receiving translational inputs (e.g., movement along x, y, and z axes). As described in further detail below, the first control member and the second control member on the unified hand controller may be repositioned by a user using a single hand to control the control target in 6-DOF.

Referring initially to FIG. **1**, an embodiment of a control system **100** is illustrated. The embodiment of the control system **100** illustrated and described below is directed to a control system for controlling a control target in 6-DOF. The control system **100** includes a controller **102** that is coupled to a signal conversion system **104** that is further coupled to a control target **106**. In an embodiment, the control target **106** may include end effectors (e.g., the end of a robotic forceps, a robotic arm and effector with snarks), camera field-of-views (e.g., including a camera center field-of-view and zoom), vehicle velocity vectors, etc. While the controller **102** and the signal conversion system **104** are illustrated separately, one of ordinary skill in the art will recognize that some or all of the controller **102** and the signal conversion system **104** may be combined without departing from the scope of the present disclosure. The controller **102** includes a first control member **102*a*** and a second control member **102*b*** that is located on the first control member **102*a***. A controller processor **102*c*** is coupled to each of the first control member **102*a*** and the second control member **102*b***. In an embodiment, the controller processor **102*c*** may be a central processing unit, a programmable logic controller, and/or a variety of other processors as may be known by one or more of ordinary skill in the art. The controller processor **102*c*** is also coupled to each of a rotational module **102*d***, a translation module **102*e***, and a transmitter **1021**. While not illustrated or described in any further detail, other connections and coupling may exist between the first control member **102*a***, the second control member **102*b***, the controller processor **102*c***, the rotation module **102*d***, the translation module **102*e***, and the transmitter **102*f*** while remaining within the scope of the present disclosure. Furthermore, components of the controller may be combined or substituted with other components as may be known by one or more of ordinary skill in the art while remaining with the scope of the present disclosure.

The signal conversion system **104** in the control system **100** includes a transceiver **104*a*** that may couple to the transmitter **102*f*** in the controller **102** through a wired connection, a wireless connection, and/or a variety of other connections as may be known by one or more of ordinary skill in the art. A conversion processor **104*b*** is coupled to the transceiver **104*a***, a control module **104*c***, and configuration parameters **104*d*** that may be included on a memory, a storage device, and/or other computer-readable mediums as may be known by one or more of ordinary skill in the art. In an embodiment, the conversion processor **104*b*** may be a central processing unit, a programmable logic controller, and/or a variety of other processors known to those of ordinary skill in the art. While not illustrated or described in any further detail, other connections and coupling may exist between the transceiver **104*a***, the conversion processor

104*b*, the control module **104***c*, and the configuration parameters **104***d* while remaining within the scope of the present disclosure. Furthermore, components of the signal conversion system **104** may be combined or substituted with other components as may be known by one or more of ordinary skill in the art while remaining with the scope of the present disclosure. The control module **104***c* may be coupled to the control target **106** through a wired connection, a wireless connection, and/or a variety of other connections as may be known by one or more of ordinary skill in the art.

In an embodiment, the controller **102** is configured to receive input from a user through the first control member **102***a* and/or the second control member **102***b* and transmit a signal based on the input. For example, the controller **102** may be provided as a "joystick" for navigating in a virtual environment (e.g., in a video game, on a real-world simulator, as part of a remote control virtual/real-world control system, and/or in a variety of other virtual environments as may be known by one or more of ordinary skill in the art.) In another example, the controller **102** may be provided as a control stick for controlling a vehicle (e.g., an aircraft, a submersible, a spacecraft, and/or a variety of other vehicles as may be known by one or more of ordinary skill in the art). In another example, the controller **102** may be provided as a control stick for controlling a robot or other non-vehicle device (e.g., a surgical device, an assembly device, and/or variety of other non-vehicle devices known to one of ordinary skill in the art).

In the embodiment discussed in further detail below, the controller **102** includes a control stick as the first control member **102***a* that is configured to be repositioned by the user. The repositioning of the control stick first control member **102***a* allows the user to provide rotational inputs using the first control member **102***a* that include pitch inputs, yaw inputs, and roll inputs, and causes the controller processor **102***c* to output rotational movement output signals including pitch movement output signals, a yaw movement output signals, and roll movement output signals. In particular, tilting the control stick first control member **102***a* forward and backward may provide the pitch input that produces the pitch movement output signal, rotating the control stick first control member **102***a* left and right about its longitudinal axis may provide the yaw input that produces the yaw movement output signal, and tilting the control stick first control member **102***a* side to side may provide the roll input that produces the roll movement output signal. As discussed below, the movement output signals that result from the repositioning of the first control member **102***a* may be reconfigured from that discussed above such that similar movements of the first control member **102***a* to those discussed above result in different inputs and movement output signals (e.g., tilting the control stick first control member **102***a* side to side may be configured to provide the yaw input that produces the yaw movement output signal while rotating the control stick first control member **102***a* about its longitudinal axis may be configured provide the roll input that produces the roll movement output signal.)

Rotational inputs using the control stick first control member **102***a* may be detected and/or measured using the rotational module **102***d*. For example, the rotational module **102***d* may include displacement detectors for detecting the displacement of the control stick first control member **102***a* from a starting position as one or more of the pitch inputs, yaw inputs, and roll inputs discussed above. Displacement detectors may include photo detectors for detecting light beams, rotary and/or linear potentiometers, inductively coupled coils, physical actuators, gyroscopes, switches, transducers, and/or a variety of other displacement detectors as may be known by one or more of ordinary skill in the art. In some embodiments, the rotational module **102***d* may include accelerometers for detecting the displacement of the control stick first control member **102***a* from a starting position in space. For example, the accelerometers may each measure the proper acceleration of the control stick first control member **102***a* with respect to an inertial frame of reference.

In other embodiments, inputs using the control stick first control member **102***a* may be detected and/or measured using breakout switches, transducers, and/or direct switches for each of the three ranges of motion (e.g., front to back, side to side, and rotation about a longitudinal axis) of the control stick first control member **102***a*. For example, breakout switches may be used to detect when the control stick first control member **102***a* is initially moved (e.g., 2.degree.) from a null position for each range of rotation, transducers may provide a signal that is proportional to the displacement of the control stick first control member **102***a* for each range of motion, and direct switches may detect when the control stick first control member **102***a* is further moved (e.g., 12.degree.) from the null position for each range of motion. The breakout switches and direct switches may also allow for acceleration of the control stick first control member **102***a* to be detected. In an embodiment, redundant detectors and/or switches may be provided in the controller **102** to ensure that the control system **100** is fault tolerant.

In the embodiment discussed in further detail below, the second control member **102***b* extends from a top, distal portion of the control stick first control member **102***a* and is configured to be repositioned by the user independently from and relative to the control stick first control member **102***a*. The repositioning of the second control member **102***b* discussed below allows the user to provide translational inputs using the second control member **102***b* that include x-axis inputs, y-axis inputs, and z-axis inputs, and causes the control processor **102***c* to output a translational movement output signals including x-axis movement output signals, y-axis movement output signals, and z-axis movement output signals. For example, tilting the second control member **102***b* forward and backward may provide the x-axis input that produces the x-axis movement output signal, tilting the second control member **102***b* side to side may provide the y-axis input that produces the y-axis movement output signal, and moving the second control member **102***b* up and down may provide the z-axis input that produces the z-axis movement output signal. As discussed below, the signals that result from the repositioning of the second control member **102***b* may be reconfigured from that discussed above such that similar movements of the second control member **102***b* to those discussed above result in different inputs and movement output signals (e.g., tilting the second control member **102***b* forward and backward may be configured to provide the z-axis input that produces the z-axis movement output signal while moving the second control member **102***b* up and down may be configured to provide the x-axis input that produces the x-axis movement output signal.) In an embodiment, the second control member **102***b* is configured to be repositioned solely by a thumb of the user while the user is gripping the control stick first control member **102***a* with the hand that includes that thumb.

Translational inputs using the second control member **102***b* may be detected and/or measured using the translation module **102***e*. For example, the translation module **102***e* may include translational detectors for detecting the displacement of the second control member **102***b* from a starting position as one or more of the x-axis inputs, y-axis inputs, and z-axis inputs discussed above. Translation detectors may include physical actuators, translational accelerometers, and/or a variety of other translation detectors as may be known by one or more of ordinary skill in the art (e.g., many of the detectors and switches discussed above for detecting and/or measuring rotational input may be repurposed for detecting and/or measuring translation input.)

In an embodiment, the controller processor **102***c* of the controller **102** is configured to generate control signals to be transmitted by the transmitter **102***f*. As discussed above, the controller processor **102***c* may be configured to generate a control signal based on one or more rotational inputs detected and/or measured by the rotational module **102***d* and/or one or more translational inputs detected and/or measured by the translation module **102***e*. Those control signal generated by the controller processor **102***c* may include parameters defining movement output signals for one or more of 6-DOF (i.e., pitch, yaw, roll, movement along an x-axis, movement along a y-axis, movement along a z-axis). In several embodiments, a discrete control signal type (e.g., yaw output signals, pitch output signals, roll output signals, x-axis movement output signals, y-axis movement output signals, and z-axis movement output signals) is produced for each discrete predefined movement (e.g., first control member **102***a* movement for providing pitch input, first control member **102***a* movement for providing yaw input, first control member **102***a* movement for providing roll input, second control member **102***b* movement for providing x-axis input, second control member **102***b* movement for providing y-axis input, and second control member **102***b* movement for providing z-axis input) that produces that discrete control signal. Beyond 6-DOF control, discrete features such as ON/OFF, trim, and other multi-function commands may be transmitted to the control target. Conversely, data or feedback may be received on the controller **102** (e.g., an indicator such as an LED may be illuminated green to indicate the controller **102** is on.)

In an embodiment, the transmitter **102***f* of the controller **102** is configured to transmit the control signal through a wired or wireless connection. For example, the control signal may be one or more of a radio frequency ("RF") signal, an infrared ("IR") signal, a visible light signal, and/or a variety of other control signals as may be known by one or more of ordinary skill in the art. In some embodiments, the transmitter **102***f* may be a BLUETOOTH® transmitter configured to transmit the control signal as an RF signal according to the BLUETOOTH® protocol (BLUETOOTH® is a registered trademark of the Bluetooth Special Interest Group, a privately held, not-for-profit trade association headquartered in Kirkland, Wash., USA).

In an embodiment, the transceiver **104***a* of the signal conversion system **104** is configured to receive the control signal transmitted by the transmitter **102***f* of the controller **102** through a wired or wireless connection, discussed above, and provide the received control signal to the conversion processor **104***b* of the signal conversion system **104**.

In an embodiment, the conversion processor **104***b* is configured to process the control signals received from the controller **102**. For example, the conversion processor **104***b* may be coupled to a computer-readable medium including instructions that, when executed by the conversion processor **104***b*, cause the conversion processor **104***b* to provide a control program that is configured to convert the control signal into movement commands and use the control module **104***c* of the signal conversion system **104** to control the control target **106** according to the movement commands. In an embodiment, the conversion processor **104***b* may convert the control signal into movement commands for a virtual three-dimensional ("3D") environment (e.g., a virtual representation of surgical patient, a video game, a simulator, and/or a variety of other virtual 3D environments as may be known by one or more of ordinary skill in the art). Thus, the control target **106** may exist in a virtual space, and the user may be provided a point of view or a virtual representation of the virtual environment from a point of view inside the control target (i.e., the control system **100** may include a display that provides the user a point of view from the control target in the virtual environment). In another example, the control target **106** may be a physical device such as a robot, an end effector, a surgical tool, a lifting system, etc., and/or a variety of steerable mechanical devices, including, without limitation, vehicles such as unmanned or remotely-piloted vehicles (e.g., "drones"); manned, unmanned, or remotely-piloted vehicles and land-craft; manned, unmanned, or remotely-piloted aircraft; manned, unmanned, or remotely-piloted watercraft; manned, unmanned, or remotely-piloted submersibles; as well as manned, unmanned, or remotely-piloted space vehicles, rocketry, satellites, and such like.

In an embodiment, the control module **104***c* of the signal conversion system **104** is configured to control movement of the control target **106** based on the movement commands provided from the control program in signal conversion system **104**. In some embodiments, if the control target **106** is in a virtual environment, the control module **104***c* may include an application programming interface (API) for moving a virtual representation or point of view within the virtual environment. API's may also provide the control module **104***c* with feedback from the virtual environment such as, for example, collision feedback. In some embodiments, feedback from the control target **106** may allow the control module **104***c* to automatically adjust the movement of the control target to, for example, avoid a collision with a designated region (e.g., objects in a real or virtual environment, critical regions of a real or virtual patient, etc.). In other embodiments, if the control target **106** is a physical device, the control module **104***c* may include one or more controllers for controlling the movement of the physical device. For example, the signal conversion system **104** may be installed on-board a vehicle, and the control module **104***c* may include a variety of physical controllers for controlling various propulsion and/or steering mechanisms of the vehicle.

In an embodiment, the signal conversion system **104** includes operating parameters **104***d* for use by the conversion processor **104***b* when generating movement commands using the signals from the controller **102**. Operating parameters may include, but are not limited to, gains (i.e., sensitivity), rates of onset (i.e., lag), deadbands (i.e., neutral), limits (i.e., maximum angular displacement), and/or a variety of other operating parameters as may be known by one or more of ordinary skill in the art. In an embodiment, the gains of the first control member **102***a* and the second control member **102***b* may be independently defined by a user. In this example, the second control member **102***b* may have increased sensitivity compared to the control stick first control member **102***a* to compensate, for example, for the second control member **102***b* having a smaller range of motion that the control stick first control member **102***a*. Similarly, the rates of onset for the first control member **102***a* and the second control member **102***b* may be defined independently to determine the amount of time that should pass (i.e., lag) before a repositioning of the first control member **102***a* and the second control member **102***b* should be converted to actual movement of the control target **106**. The limits and deadbands of the first control member **102***a* and the second control member **102***b* may be independently defined as well by calibrating the neutral and maximal positions of each.

In an embodiment, operating parameters may also define how signals sent from the controller **102** in response to the different movements of the first control member **102***a* and the second control member **102***b* are translated into movement commands that are sent to the control target. As discussed above, particular movements of the first control member **102***a* may produce pitch, yaw, and roll rotational movement output signals, while particular movements of the second control member **102***b* may produce x-axis, y-axis, and z-axis translational movement output signals. In an embodiment, the operating parameters may define which movement commands are sent to the control target **106** in response to movements and resulting movement output signals from the first control member **102***a* and second control member **102***b*.

In some embodiments, the operating parameters **104***d* may be received from an external computing device (not shown) operated by the user. For example, the external computing device may be preconfigured with software for interfacing with the controller **102** and/or the signal conversion system **104**. In other embodiments, the operating parameters **104***d* may be input directly by a user using a display screen included with the controller **102** or the signal conversion system **104**. For example, the first control member **102***a* and/or second control member **102***b* may be used to navigate a configuration menu for defining the operating parameters **104***d*.

Referring now to FIG. **2**A, FIG. **2**B, FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, and FIG. **2**G, an illustrative embodiment of an exemplary controller **200** is shown. In an embodiment, the controller **200** may be the controller **102** discussed above with reference to FIG. **1**. The controller **200** includes a base **202** including a first control member mount **202***a* that extends from the base **202** and defines a first control member mount cavity **202***b*. The base **202** may be mounted to a support using, for example, apertures **202***c* that are located in a spaced apart orientation about the circumference of the base **202** and that may be configured to accept a fastening member such as a screw. Alternatively, a dovetail fitting with a guide-installation and release or other mechanical, magnetic, or other adhesive fixation mechanism known in the art may be utilized. A first control member **204**, which may be the first control member **102***a* discussed above with reference to FIG. **1**, is coupled to the base **200** through a base coupling member **204***a* that is positioned in the first control member mount cavity **202***b*, as illustrated in FIG. **2**D. While in the illustrated embodiment, the coupling between the base coupling member **204***a* and first control member mount **202***a* is shown and described as a ball-joint coupling, one of ordinary skill in the art will recognize that a variety of other couplings between the base **202** and the first control member **204** will fall within the scope of the present disclosure. In an embodiment, a resilient member **205** such as, for example, a spring, may be positioned between the first control member **204** and the base **202** in the first control member mount cavity **202***b* in order to provide resilient movement up or down along the longitudinal axis of the first control member **204**. Furthermore, a resilient member may be provided opposite the base coupling member **204***a* from the resilient member **205** in order to limit upward movement of the first control member **204**. Furthermore, as can be seen in FIG. **2**A and FIG. **2**B, the entrance to the first control member mount cavity **202***b* may be smaller than the base coupling member **204***a* such that the first control member **204** is secured to the base **202**.

The first control member **204** includes an elongated first section **204***b* that extends from the base coupling member **204***a*. The first control member **204** also includes a grip portion **204***c* that is coupled to the first section **204***b* of the first control member **204** opposite the first section **204***b* from the base coupling member **204***a*. The grip portion **204***c* of the first control member **204** includes a top surface **204***d* that is located opposite the grip portion **204***c* from the first section of **204***b* of the first control member **204**. In the illustrated embodiments, the top surface **204***d* of the grip portion **204***c* is also a top surface of the first control member **204**. The grip portion **204***c* defines a second control member mount cavity **204***e* that extends into the grip portion **204***c* from the top surface **204***d*. A control button **206** is located on the first control member **204** at the junction of the first section **204***b* and the grip portion **204***c*. While a single control button **206** is illustrated, one of ordinary skill in the art will recognize that a plurality of control buttons may be provided at different locations on the first control member **204** without departing from the scope of the present disclosure.

A second control member **208**, which may be the second control member **102***b* discussed above with reference to FIG. **1**, is coupled to the first control member **204** through a first control member coupling member **208***a* that is positioned in the second control member mount cavity **204***e*, as illustrated in FIG. **2**D. While in the illustrated embodiment, the coupling between the first control member coupling member **208***a* and first control member **204** is shown and described as a ball-joint coupling, one of ordinary skill in the art will recognize that a variety of other couplings between the first control member **204** and the second control member **208** will fall within the scope of the present disclosure. In an embodiment, a resilient member **209** such as, for example, a spring, may be positioned between the second control member **208** and the first control member **204** in the second control member mount cavity **204***e* in order to provide resilient movement up or down in a direction that is generally perpendicular to the top surface **204***d* of the grip portion **204***c*. Furthermore, as can be seen in FIG. **2**A and FIG. **2**B, the entrance to the second control member mount cavity **204***e* may be smaller than the first control member coupling member **208***a* such that the second control member **208** is secured to and extends from the first control member **204**.

The second control member **208** includes a support portion **208***b* that extends from the first control member coupling member **208***a*. The second control member **208** also includes an actuation portion **208***c* that is coupled to the support portion **208***b* of the first control member **204** opposite the support portion **208***b* the first control member coupling member **208***a*. In the illustrated embodiments, the actuation portion **208***c* of the second control member **208** defines a thumb channel that extends through the actuation portion **208***c* of the second control member **208**. While a specific actuation portion **208***c* is illustrated, one of ordinary skill in the art will recognize that the actuation portion **208***c* may have a different structure and include a variety of other features while remaining within the scope of the present disclosure.

FIG. **2**D illustrates cabling **210** that extends through the controller **200** from the second control member **208**, through the first control member **204** (with a connection to the control button **206**), and to the base **202**. While not illustrated for clarity, one of ordinary skill in the art will recognize that some or all of the features of the controller **102**, described above with reference to FIG. **1**, may be included in the controller **200**. For example, the features of the rotational module **102***d* and the translation module **102***e* such as the detectors, switches, accelerometers, and/or other components for detecting movement of the first control member **204** and the second control member **208** may be positioned adjacent the base coupling member **204***a* and the first control member coupling member **208***a* in order to detect and measure the movement of the first control member **204** and the second control member **208**, as discussed above. Furthermore, the controller processor **102***c* and the transmitter **102***f* may be positioned, for example, in the base **202**. In an embodiment, a cord including a connector may be coupled to the cabling **210** and operable to connect the controller **200** to a control system (e.g., the control system **100**). In another embodiment, the transmitter **102***f* may allow wireless communication between the controller **200** and a control system, as discussed above.

FIG. **3**A and FIG. **3**B illustrate an embodiment of a controller **300** that is substantially similar to the controller **200**, discussed above, but with the removal of the base **202** and the base coupling member **204***a*. As discussed in further detail below, while not illustrated, one of ordinary skill in the art will recognize that some or all of the features of the controller **102**, described above with reference to FIG. **1**, may be included in the controller **300** such as, for example, features of the rotational module **102***d* including accelerometers or other devices for detecting movement of the first control member **204** in space. Furthermore, the transmitter **102***f* may be located in the first control member **204** of the controller **300** for providing wireless communication between the controller **300** and a control system, as discussed above.

In the illustrated embodiment, the second control member **208** of the controllers **200** and/or **300** is positioned on the top surface **204***d* of the apical grip portion **204***c*. The apical grip portion **204***c* for the index finger to wrap around and/or the distal group section **204***b* for the third through fifth fingers to wrap around of the first control member are configured to be grasped by a hand of a user to allow for repositioning of the first control member **204** (e.g., about its coupling to the base **202** for the controller **200**, or in space for the controller **300**) to provide the rotational inputs as discussed above. The second control member **208** is configured to be engaged by a thumb of the hand of the user (e.g., through the thumb channel) that is grasping the apical grip portion **204***c* and/or the distal grip section **204***b* of the first control member **204** to allow the thumb to reposition the second control member **208** about its coupling to the first control member **204** to provide the translational inputs discussed above. In the illustrated embodiment, the thumb channel enhances the ability of a user to reposition the second control member **208** up and down (i.e., generally perpendicular to the top surface **204***d* of the grip portion **204***c*) using the thumb, in addition to providing a full range-of-motion in a two-dimensional plane (e.g., forward, backwards, left, right) that is parallel with the top surface **204***d* of the grip portion **204***c* of the first control member **204**.

Referring now to FIG. **4**A and FIG. **4**B, a method **400** for controlling a control target is illustrated. As is the case with the other methods described herein, various embodiments may not include all of the steps described below, may include additional steps, and may sequence the steps differently. Accordingly, the specific arrangement of steps shown in FIG. **4**A should not be construed as limiting the scope of controlling the movement of a control target.

The method **400** begins at block **402** where an input is received from a user. As illustrated in FIG. **4**B, a user may grasp the first control member **204** with a hand **402***a*, while extending a thumb **402***b* through the thumb channel defined by the second control member **208**. Furthermore, the user may position a finger **402***c* over the control button **206**. One of ordinary skill in the art will recognize that while a specific embodiment having the second control member **208** positioned for thumb actuation and control button **206** for finger actuation are illustrated, other embodiments that include repositioning of the second control member **208** (e.g., for actuation by a finger other than the thumb), repositioning of the control button **206** (e.g., for actuation by a finger other than the finger illustrated in FIG. **4**B), additional control buttons, and a variety of other features will fall within the scope of the present disclosure.

In an embodiment, the input from the user at block **402** of the method **400** may include rotational inputs (i.e., a yaw input, a pitch input, and a roll input) and translational inputs (i.e., movement along an x-axis, a y-axis, and/or a z-axis) that are provided by the user using, for example, the controllers **102**, **200**, or **300**. The user may reposition the first control member **204** to provide the rotational inputs and reposition the second control member **208** to provide the translational inputs. As illustrated in FIG. **4**B, the controller **200** is "unified" in that it is capable of being operated by a single hand **402***a* of the user. In other words, the controller **200** allows the user to simultaneously provide rotational and translational inputs with a single hand without cross-coupling inputs (i.e., the inputs to the controller **200** are "pure"). As discussed above, the rotational and translational input may be detected using various devices such as photo detectors for detecting light beams, rotary and/or linear potentiometers, inductively coupled coils, physical actuators, gyroscopes, accelerometers, and a variety of other devices as may be known by one or more of ordinary skill in the art. A specific example of movements of the first control member **204** and the second control member **208** and their results on the control target **106** are discussed below, but as discussed above, any movements of the first control member **204** and the second control member **208** may be reprogrammed or repurposed to the desires of the user (including reprogramming references frames by swapping the coordinate systems based on the desires of a user), and thus the discussion below is merely exemplary of one embodiment of the present disclosure.

As illustrated in FIG. **2**C, FIG. **2**D, and FIG. **4**B, the user may use his/her hand **402***a* to move the first control member **204** back and forth along a line A (e.g., on its coupling to the base **202** for the controller **200**, by tilting the grip portion **204***c* of the first control member **204** along the line A relative to the bottom portion of the first control member **204** for the controller **300**), in order to provide pitch inputs to the controller **200** or **300**. As illustrated in FIG. **2**G and FIG. **4**B, the user may use his/her hand **402***a* to rotate the first control member **204** back and forth about its longitudinal axis on an arc B (e.g., on its coupling to the base **202** for the controller **200**, by rotating the grip portion **204***c* of the first control member **204** in space for the controller **300**), in order to provide yaw inputs to the controller **200** or **300**. As illustrated in FIG. **2**E, FIG. **2**F, and FIG. **4**B, the user may use their hand **402***a* to move the first control member **204** side to side along a line C (e.g., on its coupling to the base **202** for the controller **200**, by tiling the grip portion **204***c* of the first control member **204** along the line B relative to the bottom portion of the first control member **204** for the controller **300**), in order to provide roll inputs to the controller **200** or **300**. Furthermore, additional inputs may be provided using other features of the controller **200**. For example, the resilient member **205** may provide a neutral position of the first control member **204** such that compressing the resilient member **209** using the first control member **204** provides a first input and extending the resilient member **209** using the first control member **204** provides a second input.

As illustrated in FIG. **2**E, FIG. **2**F, FIG. **2**G, and FIG. **4**B, the user may use the thumb **402***b* to move the second control member **208** forwards and backwards along a line E (e.g., on its coupling to the first control member **204**), in order to provide x-axis inputs to the controller **200** or **300**. As illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**G, and FIG. **4**B, the user may use the thumb **402***b* to move the second control member **208** back and forth along a line D (e.g., on its coupling to the first control member **204**), in order to provide y-axis inputs to the controller **200** or **300**. As illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**E, and FIG. **2**F, and FIG. **4**B, the user may use the thumb **402***b* to move the second control member **208** up and down along a line F (e.g., on its coupling to the first control member **204** including, in some embodiments, with resistance from the resilient member **209**), in order to provide z-axis inputs to the controller **200** or **300**. In an embodiment, the resilient member **209** may provide a neutral position of the second control member **208** such that compressing the resilient member **209** using the second control member **204** provides a first z-axis input for z-axis movement of the control target **106** in a first direction, and extending the resilient member **209** using the second control member **204** provides a second z-axis input for z-axis movement of the control target **106** in a second direction that is opposite the first direction.

The method **400** then proceeds to block **404** where a control signal is generated based on the user input received in block **402** and then transmitted. As discussed above, the controller processor **102***e* and the rotational module **102***d* may generate rotational movement output signals in response to detecting and/or measuring the rotational inputs discussed above, and the control processor **102***c* and the translation module **102***e* may generate translational movement output signals in response to detecting and/or measuring the translation inputs discussed above. Furthermore, control signals may include indications of absolute deflection or displacement of the control members, rate of deflection or displacement of the control members, duration of deflection or displacement of the control members, variance of the control members from a central deadband, and/or a variety of other control signals known in the art.) For example, control signals may be generated based on the rotational and/or translational input or inputs according to the BLUETOOTH® protocol. Once generated, the control signals may be transmitted as an RF signal by an RF transmitter according to the BLUETOOTH® protocol. Those skilled in the art will appreciate that an RF signal may be generated and transmitted according to a variety of other RF protocols such as the ZIGBEE® protocol, the Wireless USB protocol, etc. In other examples, the control signal may be transmitted as an IR signal, a visible light signal, or as some other signal suitable for transmitting the control information. (ZIGBEE® is a registered trademark of the ZigBee Alliance, an association of companies headquartered in San Ramon, Calif., USA).

The method **400** then proceeds to block **406** where a transceiver receives a signal generated and transmitted by the controller. In an embodiment, the transceiver **104***a* of the signal conversion system **104** receives the control signal generated and transmitted by the controller **102**, **200**, **300**. In an embodiment in which the control signal is an RF signal, the transceiver **104***a* includes an RE sensor configured to receive a signal according to the appropriate protocol (e.g., BLUETOOTH®, ZIGBEE®, Wireless USB, etc.).

In other embodiments, the control signal may be transmitted over a wired connection. In this case, the transmitter **102***f* of the controller **102** and the transceiver **104***a* of the signal conversion system **104** may be physically connected by a cable such as a universal serial bus (USB) cable, serial cable, parallel cable, proprietary cable, etc.

The method **400** then proceeds to block **408** where control program provided by the conversion processor **104***b* of the signal conversion system **104** commands movement based on the control signals received in block **406**. In an embodiment, the control program may convert the control signals to movement commands that may include rotational movement instructions and/or translational movement instructions based on the rotational movement output signals and/or translational movement output signals in the control signals. Other discrete features such as ON/OFF, camera zoom, share capture, and so on can also be relayed. For example, the movement commands may specify parameters for defining the movement of the control target **106** in one or more DOF. Using the example discussed above, if the user uses their hand **402***a* to move the first control member **204** back and forth along a line A (illustrated in FIG. **2**C, FIG. **2**D, and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including a pitch movement instruction for modifying a pitch of the control target **106**. If the user uses their hand **402***a* to rotate the first control member **204** back and forth about its longitudinal axis about an arc B (illustrated in FIG. **2**G and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including a yaw movement instruction for modifying a yaw of the control target **106**. If the user uses their hand **402***a* to move the first control member **204** side to side along a line C (illustrated in FIG. **2**E, FIG. **2**F, and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including a roll movement instruction for modifying a roll of the control target **106**.

Furthermore, if the user uses their thumb **402***b* to move the second control member **208** forward and backwards along a line E (illustrated in FIG. **2**E, FIG. **2**F, FIG. **2**G, and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including an x-axis movement instruction for modifying the position of the control target **106** along an x-axis. If the user uses their thumb **402***b* to move the second control member **208** back and forth along a line E (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**G, and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including a y-axis movement instruction for modifying the position of the control target **106** along a y-axis. If the user uses their thumb **402***b* to move the second control member **208** side to side along a line D (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, and FIG. **4**B), the resulting control signal may be used by the control program to generate a movement command including a z-axis movement instruction for modifying the position of the control target **106** along a z-axis.

The method **400** then proceeds to block **410** where the movement of the control target **106** is performed based on the movement commands. In an embodiment, a point of view or a virtual representation of the user may be moved in a virtual environment based on the movement commands at block **410** of the method **400**. In another embodiment, an end effector, a propulsion mechanism, and/or a steering mechanism of a vehicle may be actuated based on the movement commands at block **410** of the method **400**.

FIG. **4**C, FIG. **4**D, and FIG. **4**E illustrate a control target **410***a* that may be, for example, the control target **106** discussed above, with reference to FIG. **1**. As discussed above, the control target **410***a* may include a physical vehicle in which the user is located, a remotely operated vehicle where the user operates the vehicle remotely from the vehicle, a virtual vehicle operated by the user through the provision of a point-of-view to the user from within the virtual vehicle, and/or a variety of other control targets as may be known by one or more of ordinary skill in the art. Using the example above, if the user uses their hand **402***a* to move the first control member **204** back and forth along a line A (illustrated in FIG. **2**C, FIG. **2**D, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to modify its pitch about an arc AA, illustrated in FIG. **4**D. If the user uses their hand **402***a* to rotate the first control member **204** back and forth about its longitudinal axis about an arc B (illustrated in FIG. **20** and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to modify its yaw about an arc BB, illustrated in FIG. **4**D. If the user uses their hand **402***a* to move the first control member **204** side to side along a line C (illustrated in FIG. **2**E, FIG. **2**F, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to modify its roll about an arc CC, illustrated in FIG. **4**E.

Furthermore, if the user uses his/her thumb **402***b* to move the second control member **208** forward and backwards along a line E (illustrated in FIG. **2**E, FIG. **2**F, FIG. **2**G, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to move along a line EE (i.e., its x-axis), illustrated in FIG. **4**D and FIG. **4**E. If the user uses his/her thumb **402***b* to move the second control member **208** side to side along a line D (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**G, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to move along a line DD (i.e., its y-axis), illustrated in FIG. **4**C and FIG. **4**D. If the user uses his/her thumb **402***b* to move the second control member **208** back and forth along a line F (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***a* to move along a line FF (i.e., its z-axis), illustrated in FIG. **4**C and FIG. **4**E. In some embodiments, the control button **206** and/or other control buttons on the controller **102**, **200**, or **300** may be used to, for example, actuate other systems in the control target **410***a* (e.g., weapons systems.)

FIG. **4**F illustrates a control target **410***b* that may be, for example, the control target **106** discussed above, with reference to FIG. **1**. As discussed above, the control target **410***b* may include a physical device or other tool that executed movements according to signals sent from the controller **102**, **200**, or **300**. Using the example above, if the user uses their hand **402***a* to move the first control member **204** back and forth along a line A (illustrated in FIG. **2**C, FIG. **2**D, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***b* to rotate a tool member or end effector **410***c* about a joint **410***d* along an arc AAA, illustrated in FIG. **4**F. If the user uses their hand **402***a* to rotate the first control member **204** back and forth about its longitudinal axis about an arc B (illustrated in FIG. **2**G and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***b* to rotate the tool member or end effector **410***c* about a joint **410***e* along an arc BBB, illustrated in FIG. **4**F. If the user uses his/her hand **402***a* to move the first control member **204** side to side along a line C (illustrated in FIG. **2**E, FIG. **2**F, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***b* to rotate the tool member or end effector **410***c* about a joint **410***f* along an arc CCC, illustrated in FIG. **4**F.

Furthermore, if the user uses his/her thumb **402***b* to move the second control member **208** forwards and backwards along a line E (illustrated in FIG. **2**E, FIG. **2**F, FIG. **2**G, and FIG. **4**B), the movement command resulting from the control signal generated will cause the tool member or end effector **410***c* to move along a line EEE (i.e., its x-axis), illustrated in FIG. **4**F. If the user uses his/her thumb **402***b* to move the second control member **208** back and forth along a line E (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**G, and FIG. **4**B), the movement command resulting from the control signal generated will cause the control target **410***b* to move along a line EEE (i.e., its y-axis through the joint **410***f*), illustrated in FIG. **4**F. If the user uses his/her thumb **402***b* to move the second control member **208** side to side along a line D (illustrated in FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, and FIG. **4**B), the movement command resulting from the control signal generated will cause the tool member or end effector **410***c* to move along a line DDD (i.e., its z-axis), illustrated in FIG. **4**F. In some embodiments, the control button **206** and/or other control buttons on the controller **102**, **200**, or **300** may be used to, for example, perform actions using the tool member **210***c*. Furthermore one of ordinary skill in the art will recognize that the tool member or end effector **410***c* illustrated in FIG. **4**F may be replaced or supplemented with a variety of tool members (e.g., surgical instruments and the like) without departing from the scope of the present disclosure. As discussed above, the control target **410***a* may include a camera on or adjacent the tool member or end effector **410***c* to provide a field of view to allow navigation to a target.

Referring now to FIG. **5**, a method **500** for controlling a control target is illustrated. As is the case with the other methods described herein, various embodiments may not include all of the steps described below, may include additional steps, and may sequence the steps differently. Accordingly, the specific arrangement of steps shown in FIG. **5** should not be construed as limiting the scope of controlling the movement of a control target.

The method **500** may begin at block **502** where rotational input is received from a user. The user may provide rotational input by repositioning the first control member **204** of the controller **200** or **300** similarly as discussed above. In some embodiments, the rotational input may be manually detected by a physical device such as an actuator. In other embodiments, the rotational input may be electrically detected by a sensor such as an accelerometer.

The method **500** may proceed simultaneously with block **504** where translational input is received from the user. The user may provide translational input by repositioning the second control member **208** of the controller **200** or **300** similarly as discussed above. The rotational input and the translational input may be provided by the user simultaneously using a single hand of the user. In some embodiments, the translational input may be manually detected by a physical device such as an actuator.

In an embodiment, the rotational and translational input may be provided by a user viewing the current position of a control target **106** on a display screen. For example, the user may be viewing the current position of a surgical device presented within a virtual representation of a patient on a display screen. In this example, the rotational input and translational input may be provided using the current view on the display screen as a frame of reference.

The method **500** then proceeds to block **506** where a control signal is generated based on the rotational input and translational input and then transmitted. In the case of the rotational input being manually detected, the control signal may be generated based on the rotational input and translational input as detected by a number of actuators, which convert the mechanical force being asserted on the first control member **204** and the second control member **208** to an electrical signal to be interpreted as rotational input and translational input, respectively. In the case of the rotational input being electronically detected, the control signal may be generated based on rotational input as detected by accelerometers and translational input as detected by actuators.

In an embodiment, a control signal may be generated based on the rotational input and translational input according to the BLUETOOTH® protocol. Once generated, the control signal may be transmitted as an RF signal by an RF transmitter according to the BLUETOOTH® protocol. One of ordinary skill in the art will appreciate that an RF signal may be generated and transmitted according to a variety of other RF protocols such as the ZIGBEE® protocol, the Wireless USB protocol, etc. In other examples, the control signal may be transmitted as an IR signal, visible light signal, or as some other signal suitable for transmitting the control information.

The method **500** then proceeds to block **508**, the transceiver **104***a* of the signal conversion system **104** receives the control signal. In the case that the control signal is an RF signal, the transceiver **104***a* includes an RF sensor configured to receive a signal according to the appropriate protocol (e.g., BLUETOOTH®, ZIGBEE®, Wireless USB, etc.). In other embodiments, the control signal may be transmitted over a wired connection. In this case, the transmitter **102***f* and the transceiver **104***a* are physically connected by a cable such as a universal serial bus (USB) cable, serial cable, parallel cable, proprietary cable, etc.

The method **500** then proceeds to block **510** where the conversion processor **104***b* commands movement in 6 DOF based on the received control signal. Specifically, the control signal may be converted to movement commands based on the rotational and/or translational input in the control signal. The movement commands may specify parameters for defining the movement of a point of view or a virtual representation of the user in one or more DOF in a virtual 3D environment. For example, if the second control member **208** is repositioned upward by the user, the resulting control signal may be used to generate a movement command for moving a point of view of a surgical device up along the z-axis within a 3D representation of a patient's body. In another example, if the first control member **204** is tilted to the left and the second control member **208** is repositioned downward, the resulting control signal may be used to generate movement commands for rolling a surgical device to the left while moving the surgical device down along a z-axis in the 3D representation of the patient's body. Any combination of rotational and translational input may be provided to generate movement commands with varying combinations of parameters in one or more DOF.

The method **500** then proceeds to block **512** where a proportional movement is performed in the virtual and/or real environment based on the movement commands. For example, a point of view of a surgical device in a virtual representation of a patient may be repositioned according to the movement commands, where the point of view corresponds to a camera or sensor affixed to a surgical device. In this example, the surgical device may also be repositioned in the patient's body according to the movement of the surgical device in the virtual representation of the patient's body. The unified controller allows the surgeon to navigate the surgical device in 6-DOF within the patient's body with a single hand.

Referring now to FIG. **6**, a method **600** for configuring a controller is illustrated. As is the case with the other methods described herein, various embodiments may not include all of the steps described below, may include additional steps, and may sequence the steps differently. Accordingly, the specific arrangement of steps shown in FIG. **6** should not be construed as limiting the scope of controlling the movement of a control target.

The method **600** begins at block **602** where the controller **102** is connected to an external computing device. The controller **102** may be connected via a physical connection (e.g., USB cable) or any number of wireless protocols (e.g., BLUETOOTH® protocol). The external computing device may be preconfigured with software for interfacing with the controller **102**.

The method **600** then proceeds to block **604** where configuration data is received by the controller **102** from the external computing device. The configuration data may specify configuration parameters such as gains (i.e., sensitivity), rates of onset (i.e., lag), deadbands (i.e., neutral), and/or limits (i.e., maximum angular displacement). The configuration data may also assign movement commands for a control target to movements of the first control member and second control member. The configuration parameters may be specified by the user using the software configured to interface with the controller **102**.

The method **600** then proceeds to block **606** where the operating parameters of the controller **102** are adjusted based on the configuration data. The operating parameters may be stored in memory and then used by the controller **102** to remotely control a control target as discussed above with respect to FIG. **4**A and FIG. **5**. In some embodiments, the method **600** may include the ability to set "trim", establish rates of translation (e.g., cm/sec) or reorientation (e.g., deg/sec), or initiate "auto-sequences" to auto-pilot movements (on a display or on the controller **102** itself.)

In other embodiments, the controller **102** may be equipped with an input device that allows the user to directly configure the operating parameters of the controller **102**. For example, the controller **102** may include a display screen with configuration menus that are navigable using the first control member **204** and/or the second control member **208**.

A computer readable program product stored on a tangible storage media may be used to facilitate any of the preceding embodiments such as, for example, the control program discussed above. For example, embodiments of the invention may be stored on a computer readable medium such as an optical disk [e.g., compact disc (CD), digital versatile disc (DVD), etc.], a diskette, a tape, a file, a flash memory card, or any other computer readable storage device. In this example, the execution of the computer readable program product may cause a processor to perform the methods discussed above with respect to FIG. **4**A, FIG. **5**, and FIG. **6**.

Referring now to FIG. **7**A and FIG. **7**B, a controller **700** is illustrated that is substantially similar in structure and operation to the controller **200**, discussed above with reference to FIG. **2**A, FIG. **2**B, FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, FIG. **2**G, FIG. **4**A, FIG. **4**B, FIG. **4**C, FIG. **4**D, FIG. **4**E, FIG. **4**F, FIG. **5**, and FIG. **6**, with the provision of a second control member **702** replacing the second control member **208**, and a plurality of control buttons **704***a* and **704***b* in place of the control button **206**. The second control member **702** is substantially similar in structure and operation to the second control member **208**, but is positioned on a front surface of the controller **102** at the junction of the first section **204***b* and the grip portion **204***c* of the first control member **204**. The control button **704***a* is located on the top surface **204***d* of the grip portion **204***c* of the first control member **204**, while the control buttons **704***b* are located on the front surface of the controller **102** below the second control member **702**.

In operation, the first control member **204** may operate substantially as described above according to the methods **400** and **500**. However, inputs provided using the second control member **702** be configured to provide different control signals. For example, the user may use the index finger **402***c* (illustrated in FIG. **4**B) to move the second control member **702** side to side along a line G (e.g., on its coupling to the first control member **204**), in order to provide y-axis inputs to the controller **700**. Furthermore, the user may use the index finger **402***c* to move the second control member **702** up and down along a line H (e.g., on its coupling to the first control member **204**), in order to provide z-axis inputs to the controller **700**. Further still, the user may use the finger **402***c* to move the second control member **702** forward and backward along a line I (e.g., on its coupling to the first control member **204** including, in some embodiments, with resistance from a resilient member similar to the resilient member **209**), in order to provide x-axis inputs to the controller **700**. In an embodiment, the resilient member may provide a neutral position of the second control member **702** such that compressing the resilient member using the second control member **702** provides a first y-axis input for y-axis movement of the control target **106** in a first direction, and extending the resilient member using the second control member **702** provides a second y-axis input for y-axis movement of the control target **106** in a second direction that is opposite the first direction. Furthermore, the control buttons **704***a* and **704***b* may be actuated to control a variety of other systems on the control target, as discussed above.

Referring now to FIG. **8**A and FIG. **8**B, a controller **800** is illustrated that is substantially similar in structure and operation to the controller **200**, discussed above with reference to FIG. **2**A, FIG. **2**B, FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, FIG. **2**G, FIG. **4**A, FIG. **4**B, FIG. **4**C, FIG. **4**D, FIG. **4**E, FIG. **4**F, FIG. **5**, and FIG. **6**, with the provision of a second control member **802** replacing the second control member **208**, and a plurality of control buttons **804** in place of the control button **206**. The second control member **802** is similar in structure and operation to the second control member **208**, but includes an actuation portion **802***a* replacing the actuation portion **208***c*. As can be seen, the actuation portion **802***a* does not include the thumb channel defined by the actuation portion **208***c*. The control buttons **804** are located on the front surface of the controller **102**.

In operation, the first control member **204** may operate substantially as described above according to the methods **400** and **500**. The second control member **802** may operate substantially as described above for the second control member **208** according to the methods **400** and **500**, but with some modifications. For example, some inputs provided using the second control member **802** be configured to provide different control signals. For example, the user may use the thumb **402***c* to move the second control member **802** up and down along a line J (e.g., on its coupling to the first control member **204**) by compressing the resilient member **209** in order to provide z-axis inputs to the controller **800**. In some embodiments, compressing the resilient member **209** initially may provide a first z-axis input for z-axis movement of the control target **106** in a first direction, while a release of the second control member **802** and then a recompression of the resilient member **209** using the second control member **802** may provide a second z-axis input for z-axis movement of the control target **106** in a second direction that is opposite the first direction. In other embodiments, one of the control buttons **804** may determine which z-axis direction compressing the second control member **802** will provide (e.g., with a control button **804** in a first position, compressing the second control member **802** will provide a z-axis input for z-axis movement of the control target in a first direction, while with that control button **804** in a second position, compressing the second control member **802** will provide a z-axis input for z-axis movement of the control target in a second direction that is opposite the first direction.) Furthermore, the control buttons **804** may be actuated to control a variety of other systems on the control target, as discussed above.

Referring now to FIG. **9**A and FIG. **9**B, a controller **900** is illustrated that is substantially similar in structure and operation to the controller **200**, discussed above with reference to FIG. **2**A, FIG. **2**Bb, FIG. **2**C, FIG. **2**D, FIG. **2**E, FIG. **2**F, FIG. **2**G, FIG. **4**A, FIG. **4**B, FIG. **4**C, FIG. **4**D, FIG. **4**E, FIG. **4**F, FIG. **5**, and FIG. **6**, with the provision of a second control member **902** replacing the second control member **208**. The second control member **902** is a compressible button having first direction actuation portions **902***a*, second direction actuation portions **902***b*, and third direction actuation portion **902***c*.

In operation, the first control member **204** may operate substantially as described above according to the methods **400** and **500**. The second control member **802** may operate substantially as described above for the second control member **208** according to the methods **400** and **500**, but with some modifications. For example, the user may use the thumb **402***b* to press the actuation portions **902***a* on the second control member **902** in order to provide x-axis inputs to the controller **900**. Furthermore, the user may use the thumb **402***b* to press the actuation portions **902***b* on the second control member **902** in order to provide y-axis inputs to the controller **900**. Further still, the user may use the thumb **402***b* to press the actuation portion **902***c* on the second control member **902** in order to provide z-axis inputs to the controller **900**. In an embodiment, pressing the actuation portion **902***c* on the second control member **902** may provide a first z-axis input for z-axis movement of the control target **106** in a first direction, while releasing and then re-pressing the actuation portion **902***c* on the second control member **702** may provide a second z-axis input for z-axis movement of the control target **106** in a second direction that is opposite the first direction. In other embodiments, the control button **206** may determine which z-axis direction pressing the actuation portion **902***c* on the second control member **902** will provide (e.g., with a control button **206** in a first position, pressing the actuation portion **902***c* on the second control member **902** will provide a z-axis input for z-axis movement of the control target in a first direction, while with that control button **804** in a second position, pressing the actuation portion **902***c* on the second control member **902** will provide a z-axis input for z-axis movement of the control target in a second direction that is opposite the first direction.)

Thus, a system and method have been described that that include a controller that allows a user to provide rotational and translational commands in six independent degrees of freedom using a single hand. The system and method may be utilized in a wide variety of control scenarios. While a number of control scenarios are discussed below, those examples are not meant to be limiting, and one of ordinary skill in the art will recognize that any control scenario may benefit from being able to provide rotational and translational movement using a single hand.

In an embodiment, the control systems and methods discussed above may be utilized in a wide variety of medical applications. While a number of medical applications are discussed below, those examples are not meant to be limiting, and one of ordinary skill in the art will recognize that many other medical applications may benefit from being able to provide rotational and translational movement using a single hand. Furthermore, in such embodiments, in addition to the rotational and translational movement provided using first and second control members discussed above, control buttons (e.g., the control button **206** on controllers **200** or **300** and/or other control buttons) may be configured for tasks such as, for example, end-effector capture, biopsy, suturing, radiography, photography, and/or a variety of other medical tasks as may be known by one or more of ordinary skill in the art.

For example, the control systems and methods discussed above may provide a control system for performing laparoscopic surgery and/or a method for performing laparoscopic surgery. Conventional laparoscopic surgery is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing laparoscopic surgery, including fine dexterous manipulation of one or more surgical instruments, potentially without a straight and rigid path to the end effector.

In another example, the control systems and methods discussed above may provide a control system for performing minimally invasive or natural orifice surgery and/or a method for performing minimally-invasive or natural-orifice surgery. Conventional minimally invasive or natural orifice surgery is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing minimally invasive or natural orifice surgery, including fine dexterous manipulation of one or more surgical tools, potentially without a straight and rigid path to the end effector.

In another example, the control systems and methods discussed above may provide a control system for performing prenatal intrauterine surgery and/or a method for performing prenatal surgery. Conventional prenatal surgery is performed using control systems that require both hands of a surgeon to operate the control system in very tight confines. Using the control systems and/or the methods discussed above provide several benefits in performing prenatal surgery, including fine dexterous manipulation of one or more surgical tools, potentially without a straight and rigid path to the end effector.

For any of the above surgical examples, the control systems and methods discussed above may provide a very stable control system for performing microscopic surgery and/or a method for performing microscopic surgery. Using the control systems and/or the methods discussed above provide several benefits in performing microscopic surgery, including highly accurate camera and end effector pointing.

In another example, the control systems and methods discussed above may provide a control system for performing interventional radiology and/or a method for performing interventional radiology. Conventional interventional radiology is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing interventional radiology, including highly accurate navigation through for interventional radiology.

In another example, the control systems and methods discussed above may provide a control system for performing interventional cardiology and/or a method for performing interventional cardiology. Conventional interventional cardiology is performed using control systems that require both hands of an interventionist to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing interventional cardiology, including highly accurate navigation through the vascular tree using one hand.

In another example, the control systems and methods discussed above may provide a control system including Hansen/Da Vinci robotic control and/or a method for performing Hansen/Da Vinci robotic control. Conventional Hansen/Da Vinci robotic control is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing Hansen/Da Vinci robotic control, including fluid, continuous translation and reorientation without shuffling the end effector for longer motions.

In another example, the control systems and methods discussed above may provide a control system for performing 3D- or 4D-image guidance and/or a method for performing 3D- or 4D-image guidance. Conventional 3D- or 4D-image guidance is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing 3D- or 4D-image guidance, including fluid, continuous translation and reorientation without shuffling the end effector for longer motions.

In another example, the control systems and methods discussed above may provide a control system for performing endoscopy and/or a method for performing endoscopy. Conventional endoscopy is performed using control systems that require both hands of a surgeon to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in performing endoscopy, including fluid, continuous translation and reorientation without shuffling the end effector for longer motions. This also applies to colonoscopy, cystoscopy, bronchoscopy, and other flexible inspection scopes.

In an embodiment, the control systems and methods discussed above may be utilized in a wide variety of defense or military applications. While a number of defense or military applications are discussed below, those examples are not meant to be limiting, and one of ordinary skill in the art will recognize that many other defense or military applications may benefit from being able to provide rotational and translational movement using a single hand.

For example, the control systems and methods discussed above may provide a control system for unmanned aerial systems and/or a method for controlling unmanned aerial systems. Conventional unmanned aerial systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling unmanned aerial systems, including intuitive single-handed, precise, non-cross-coupled motion within the airspace.

In another example, the control systems and methods discussed above may provide a control system for unmanned submersible systems and/or a method for controlling unmanned submersible systems. Conventional unmanned submersible systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling unmanned submersible systems, including intuitive single-handed, precise, non-cross-coupled motion within the submersible space.

In another example, the control systems and methods discussed above may provide a control system for weapons targeting systems and/or a method for controlling weapons targeting systems. Conventional weapons targeting systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling weapons targeting systems, including precise, intuitive, single-handed targeting.

In another example, the control systems and methods discussed above may provide a control system for counter-improvised-explosive-device (TED) systems and/or a method for controlling counter-IED systems. Conventional counter-IED systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling counter-IED systems, including precise, intuitive, single-handed pointing or targeting.

In another example, the control systems and methods discussed above may provide a control system for heavy mechanized vehicles and/or a method for controlling heavy mechanized vehicles. Conventional heavy mechanized vehicles are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling heavy mechanized vehicles, including precise, intuitive, single-handed targeting.

In another example, the control systems and methods discussed above may provide a control system for piloted aircraft (e.g., rotary wing aircraft) and/or a method for controlling piloted aircraft. Conventional piloted aircraft are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling piloted aircraft, including precise, intuitive, single-handed, non-cross-coupled motion within the airspace for the piloted aircraft.

In another example, the control systems and methods discussed above may provide a control system for spacecraft rendezvous and docking and/or a method for controlling spacecraft rendezvous and docking. Conventional spacecraft rendezvous and docking is controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling spacecraft rendezvous and docking, including precise, intuitive, single-handed, non-cross-coupled motion within the space for rendezvous and/or docking.

In another example, the control systems and methods discussed above may provide a control system for air-to-air refueling (e.g., boom control) and/or a method for controlling air-to-air refueling. Conventional air-to-air refueling is controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling air-to-air refueling, including precise, intuitive, single-handed, non-cross-coupled motion within the airspace for refueling.

In another example, the control systems and methods discussed above may provide a control system for navigation in virtual environments (e.g., operational and simulated warfare) and/or a method for controlling navigation in virtual environments. Conventional navigation in virtual environments is controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling navigation in virtual environments, including precise, intuitive, single-handed, non-cross-coupled motion within the virtual environment.

In an embodiment, the control systems and methods discussed above may be utilized in a wide variety of industrial applications. While a number of industrial applications are discussed below, those examples are not meant to be limiting, and one of ordinary skill in the art will recognize that many other industrial applications may benefit from being able to provide rotational and translational movement using a single hand.

For example, the control systems and methods discussed above may provide a control system for oil exploration systems (e.g., drills, 3D visualization tools, etc.) and/or a method for controlling oil exploration systems. Conventional oil exploration systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling oil exploration systems, including precise, intuitive, single-handed, non-cross-coupled motion within the formation.

In another example, the control systems and methods discussed above may provide a control system for overhead cranes and/or a method for controlling overhead cranes. Conventional overhead cranes are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide a benefit in controlling overhead cranes where single axis motion is often limited, by speeding up the process and increasing accuracy.

In another example, the control systems and methods discussed above may provide a control system for cherry pickers or other mobile industrial lifts and/or a method for controlling cherry pickers or other mobile industrial lifts. Conventional cherry pickers or other mobile industrial lifts are often controlled using control systems that require both hands of an operator to operate the control system, and often allow translation (i.e., x, y, and/or z motion) in only one direction at a time. Using the control systems and/or the methods discussed above provide several benefits in controlling cherry pickers or other mobile industrial lifts, including simultaneous multi-axis motion via a single-handed controller.

In another example, the control systems and methods discussed above may provide a control system for firefighting systems (e.g., water cannons, ladder trucks, etc.) and/or a method for controlling firefighting systems. Conventional firefighting systems are often controlled using control systems that require both hands of an operator to operate the control system, and typically do not allow multi-axis reorientation and translation. Using the control systems and/or the methods discussed above provide several benefits in controlling firefighting systems, including simultaneous multi-axis motion via a single-handed controller.

In another example, the control systems and methods discussed above may provide a control system for nuclear material handling (e.g., gloveboxes, fuel rods in cores, etc.) and/or a method for controlling nuclear material handling. Conventional nuclear material handling systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling nuclear material handling, including very precise, fluid, single-handed, multi-axis operations with sensitive materials.

In another example, the control systems and methods discussed above may provide a control system for steel manufacturing and other high temperature processes and/or a method for controlling steel manufacturing and other high temperature processes. Conventional steel manufacturing and other high temperature processes are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling steel manufacturing and other high temperature processes, including very precise, fluid, single-handed, multi-axis operations with sensitive materials.

In another example, the control systems and methods discussed above may provide a control system for explosives handling (e.g., in mining applications) and/or a method for controlling explosives handling. Conventional explosives handling is controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling explosives handling, including very precise, fluid, single-handed, multi-axis operations with sensitive materials.

In another example, the control systems and methods discussed above may provide a control system for waste management systems and/or a method for controlling waste management systems. Conventional waste management systems are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling waste management systems, including very precise, fluid, single-handed, multi-axis operations with sensitive materials.

In an embodiment, the control systems and methods discussed above may be utilized in a wide variety of consumer applications. While a number of consumer applications are discussed below, those examples are not meant to be limiting, and one of ordinary skill in the art will recognize that many other consumer applications may benefit from being able to provide rotational and translational movement using a single hand.

For example, the control systems and methods discussed above may provide a control system for consumer electronics devices [e.g., Nintendo WHO (Nintendo of America Inc., Redmond, Wash., USA), Nintendo DS®, Microsoft XBox® (Microsoft Corp., Redmond, Wash., USA), Sony Playstation® (Sony Computer Entertainment Inc., Corp., Tokyo, Japan)], and other video consoles as may be known by one or more of ordinary skill in the art) and/or a method for controlling consumer electronics devices. Conventional consumer electronics devices are controlled using control systems that require both hands of an operator to operate the control system (e.g., a hand controller and keyboard, two hands on one controller, a Wii® "nunchuck" z-handed I/O device, etc.) Using the control systems and/or the methods discussed above provide several benefits in controlling consumer electronics devices, including the ability to navigate with precision through virtual space with fluidity, precision and speed via an intuitive, single-handed controller.

In another example, the control systems and methods discussed above may provide a control system for computer navigation in 3D and/or a method for controlling computer navigation in 3D. Conventional computer navigation in 3D is controlled using control systems that either require both hands of an operator to operate the control system or do not allow fluid multi-axis motion through space. Using the control systems and/or the methods discussed above provide several benefits in controlling computer navigation in 3D, including very precise, fluid, single-handed, multi-axis operations.

In another example, the control systems and methods discussed above may provide a control system for radio-controlled vehicles and/or a method for controlling radio-controlled vehicles. Conventional radio-controlled vehicles are controlled using control systems that require both hands of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling radio-controlled vehicles, including intuitive single-handed, precise, non-cross-coupled motion within the airspace for radio-controlled vehicles.

In another example, the control systems and methods discussed above may provide a control system for 3D computer aided drafting (CAD) image manipulation and/or a method for controlling 3D CAD image manipulation. Conventional 3D CAD image manipulation is controlled using control systems that either require both hands of an operator to operate the control system or do not allow fluid multi-axis motion through 3D space. Using the control systems and/or the methods discussed above provide several benefits in controlling 3D CAD image manipulation, including intuitive single-handed, precise, non-cross-coupled motion within the 3D space.

In another example, the control systems and methods discussed above may provide a control system for general aviation and/or a method for controlling general aviation. Conventional general aviation is controlled using control systems that require both hands and feet of an operator to operate the control system. Using the control systems and/or the methods discussed above provide several benefits in controlling general aviation, including intuitive single-handed, precise, non-cross-coupled motion within the airspace for general aviation.

It is understood that variations may be made in the above without departing from the scope of the invention. While specific embodiments have been shown and described, modifications can be made by one skilled in the art without departing from the spirit or teaching of this invention. The embodiments as described are exemplary only and are not limiting. Many variations and modifications are possible and are within the scope of the invention. Furthermore, one or more elements of the exemplary embodiments may be omitted, combined with, or substituted for, in whole or in part, with one or more elements of one or more of the other exemplary embodiments. Accordingly, the scope of protection is not limited to the embodiments described, but is only limited by the claims that follow, the scope of which shall include all equivalents of the subject matter of the claims.

The invention claimed is:

1. A controller for a remotely piloted aircraft movable forward and backward along an x-axis of the remotely piloted aircraft, side to side along a y-axis of the remotely piloted aircraft, and up and down along a z-axis of the remotely piloted aircraft, the controller comprising:

a first control member configured to be grasped by the fingers of a user's hand, the first control member having a top surface and a cavity extending into the first control member from the top surface,

a second control member having a ball-shaped coupling member, a support portion extending from the coupling member, and an actuation portion coupled to the support portion and defining a thumb channel configured to be engaged by the thumb of the user's hand,

the coupling member positioned in the cavity of the first control member for rotational movement relative to the first control member to enable the actuation portion to be moved through a first, forward and backward degree of freedom, and a second, side to side degree of freedom,

the second control member further being coupled to the first control member to enable the actuation portion to be moved relative to the first control member through a third, up and down degree of freedom,

the first control member and the second control member being configured so that while the first control member is grasped by the fingers of the user's hand, the second control member is movable by the user's thumb, disposed in the thumb channel, relative to the first control member through the three degrees of freedom to provide in response thereto a corresponding set of three control inputs;

wherein movement of the actuation portion of the second control member in the first degree of freedom produces an x-axis control input, in the second degree of freedom produces a y-axis control input, and in the third degree of freedom produces a z-axis control input; and

a controller processor connectable to receive the set of control inputs and generate therefrom a set of control signals for the remotely-piloted aircraft, the set of control signals including:

an x-axis control signal corresponding to the x-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's x-axis,

a y-axis control signal corresponding to the y-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's y-axis, and

a z-axis control signal corresponding to the z-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's z-axis.

2. The controller of claim **1**, further comprising a transmitter connectable to the controller processor to receive the set of control signals and transmit the set of control signals to the remotely-piloted aircraft.

3. The controller of claim **1**, further comprising:

a control button located on the first control member and operable by a finger of the user when the first control member is grasped by the user's hand, the control button operable to actuate a system on the remotely-piloted aircraft.

4. The controller of claim **1**, further comprising the remotely piloted aircraft.

5. The controller of claim **1**, wherein the remotely-piloted aircraft is a drone.

6. The controller of claim **1**, wherein the coupling member enables the actuation portion to be moved through a full range-of-motion in a two-dimensional plane that is parallel with the top surface of the first control member.

7. The controller of claim **1**, wherein the remotely-piloted aircraft is a virtual aircraft.

8. The controller of claim **1**, wherein the remotely-piloted aircraft is further movable in yaw, the first control member is configured so that while the first control member is grasped by the fingers of the user's hand, at least a portion of the first control member is movable by the user to provide in response thereto a yaw control input, and the controller processor can receive the yaw control input and generate therefrom a yaw control signal commanding the remotely-piloted aircraft to yaw.

9. A method of controlling the movement of a remotely-piloted aircraft movable forward and backward along an x-axis of the remotely-piloted aircraft, side to side along a y-axis of the remotely-piloted aircraft, and up and down along a z-axis of the remotely-piloted aircraft, using a controller having a first control member having a top surface, a second control member having an actuation portion disposed above the top surface of the control member, having a thumb channel, and movable relative to the first control member through a first, forward and backward degree of freedom, a second, side to side degree of freedom, and a third, up and down degree of freedom, movement of the actuation portion of the second control member in the first degree of freedom producing an x-axis control input, in the second degree of freedom producing a y-axis control input, and in the third degree of freedom producing a z-axis control input, a controller processor configured to receive the set of control inputs and generate a set of control signals, and a transmitter connected to the controller processor to receive the set of control signals and transmit the set of control signals to the remotely-piloted aircraft, the set of control signals including an x-axis control signal corresponding to the x-axis control input and commanding the remotely-piloted aircraft to move along the aircraft's x-axis, a y-axis control signal corresponding to the y-axis control input and commanding the remotely-piloted aircraft to move along the aircraft's y-axis, and a z-axis control signal corresponding to the z-axis control input and commanding the remotely-piloted aircraft to move along the aircraft's z-axis, the method comprising:

grasping with the fingers of a user's hand the first control member below the top surface;

inserting the thumb of the user's hand into the thumb channel of the actuation portion of the second control member;

moving the actuation portion forward relative to the first control member to cause the controller to generate an x-axis control input and thereby to cause the controller to generate an x-axis control signal to cause the remotely-piloted aircraft to move forward along the aircraft's x-axis;

moving the actuation portion to a first side relative to the first control member to cause the controller to generate a y-axis control input and thereby to cause the controller to generate a y-axis control signal to cause the remotely-piloted aircraft to move to a first side along the remotely-piloted aircraft's y-axis; and

moving the actuation portion upward relative to the top surface of the first control member to cause the controller to generate a z-axis control input and thereby to cause the controller to generate a z-axis control signal to cause the remotely-piloted to move upward along the remotely-piloted aircraft's z-axis.

10. The method of claim **9**, further comprising moving the actuation portion backward relative to the first control member to cause the controller to generate an x-axis control input and thereby to cause the controller to generate an x-axis control signal to cause the remotely-piloted aircraft to move backward along the aircraft's x-axis.

11. The method of claim **9**, further comprising moving the actuation portion to a second side, opposite to the first side, relative to the first control member to cause the controller to generate a y-axis control input and thereby to cause the controller to generate an y-axis control signal to cause the remotely-piloted aircraft to move to a second side, opposite to the first side, along the aircraft's y-axis.

12. The method of claim **9**, further comprising moving the actuation portion downward relative to the first control member to cause the controller to generate a z-axis control input and thereby to cause the controller to generate a z-axis control signal to cause the remotely-piloted aircraft to move downward along the aircraft's z-axis.

13. The method of claim **9**, wherein the controller further includes a control button located on the first control member and operable to actuate a system on the remotely-piloted aircraft, the method further comprising:

positioning a finger of the user on the control button while the user is grasping the first control member; and

operating the control button with the user's finger to cause the controller to generate, and the transmitter to transmit to the remotely-piloted aircraft, a control signal to actuate the system on the remotely-piloted aircraft.

14. The controller of claim **9**, wherein the remotely-piloted aircraft is a virtual aircraft.

15. A non-transitory computer-readable medium storing code representing instructions to be executed by a processor coupled to a controller having a first control member having a top surface, a second control member having an actuation portion disposed above the top surface of the control member, having a thumb channel, and movable relative to the first control member through a first, forward and backward degree of freedom, a second, side to side degree of freedom, and a third, up and down degree of freedom, movement of the actuation portion of the second control member in the first degree of freedom producing an x-axis control input, in the second degree of freedom producing a y-axis control input, and in the third degree of freedom producing a z-axis control input, the code comprising code to cause the processor to:

receive an x-axis control input produced by movement of the second control member in the first degree of freedom, generate an x-axis control signal corresponding to the x-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's x-axis, and send the x-axis control signal to a transmitter to transmit the control signal to the remotely-piloted aircraft;

receive a y-axis control input produced by movement of the second control member in the second degree of freedom, generate a y-axis control signal corresponding to the y-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's y-axis, and send the y-axis control signal to the transmitter to transmit the control signal to the remotely-piloted aircraft; and

receive a z-axis control input produced by movement of the second control member in the third degree of freedom, generate a z-axis control signal corresponding to the z-axis control input and commanding the remotely-piloted aircraft to move along the remotely-piloted aircraft's z-axis, and send the z-axis control signal to the transmitter to transmit the control signal to the remotely-piloted aircraft.

16. The non-transitory computer-readable medium of claim **15**, wherein the first control member further includes a control button located on the first control member and operable to produce an additional control input, wherein the code further comprises code to cause the processor to receive the additional control input produced by operation of the control button by the finger of a user, to generate an additional control signal commanding the actuation of a system on the remotely-piloted aircraft, and to send the additional control signal to the transmitter to transmit the additional control signal to the remotely-piloted aircraft.

17. The controller of claim **15**, wherein the remotely-piloted aircraft is a virtual aircraft.

18. A controller, comprising:

a first control member configured to be grasped by the fingers of a user's hand, the first control member having a top surface,

a second control member having an actuation portion disposed above the top surface of the first control member and defining a thumb channel configured to be engaged by the thumb of the user's hand while the first control member is grasped by the fingers of the user's hand, the second control member being movable relative to the first control member back and forth through three continuous and independent degrees of freedom to provide in response thereto a corresponding set of three independent control inputs; and

a controller processor connectable to receive the set of control inputs and generate therefrom a set of control signals,

wherein the set of control signals corresponds to three independent translational movements of the control target and are proportional to the displacement of the second control member through the corresponding set of degrees of freedom.

19. The controller of claim **18**, wherein the control target is a remotely-piloted aerial vehicle having three independent and continuous translational movements corresponding the set of control signals.

20. The controller of claim **19**, wherein the remotely-piloted aerial vehicle is a virtual vehicle.

21. The controller of claim **19**, further comprising the remotely-piloted aerial vehicle.

22. The controller of claim **18**, further comprising a transmitter connectable to the controller processor to receive the set of control signals and transmit the set of control signals to the control target.

23. The controller of claim **18**, wherein the actuation portion of the second control member is coupled to the first control member by a support portion.

24. The controller of claim **23**, wherein the support portion is coupled to the first control member by a ball and socket joint.

25. The controller of claim **18**, wherein the actuation portion of the second control member is movable by the user's thumb in a first, forward and backward degree of freedom, in a second, side to side degree of freedom, and in a third, up and down degree of freedom.

26. The controller of claim **25**, wherein movement of the actuation portion of the second control member in the first degree of freedom produces an x-axis movement signal, in the second degree of freedom produces a y-axis movement signal, and in the third degree of freedom produces a z-axis movement signal.

27. The controller of claim **18**, further comprising a display screen.

28. The controller of claim **18**, further comprising a control button located on the first control member and operable by a finger of the user when the first control member is grasped by the user's hand, the control button operable to actuate a system on the control target.

* * * * *