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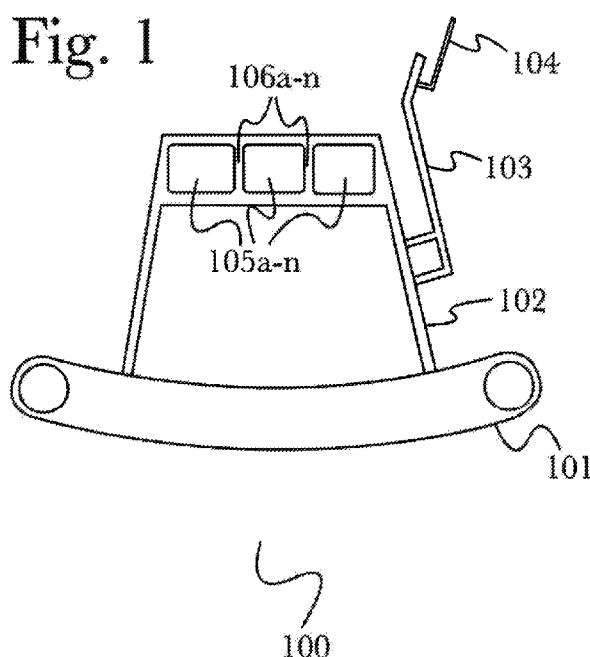
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(54) Title: VARIABLE-RESISTANCE EXERCISE MACHINE WITH WIRELESS COMMUNICATION FOR SMART DEVICE CONTROL AND INTERACTIVE SOFTWARE APPLICATIONS

Fig. 1



(57) Abstract: A variable-resistance exercise machine with wireless communication for smart device control and interactive software applications, comprising a wireless network interface that receives input from a user device and provides output to a user device; a plurality of moving surfaces that each provide an independent degree of resistance to movement based on received input and that detect movement and provide output to a user device based on the movement; and a plurality of rigid rails that provide a rigid support for a human user to grasp, and that provide attachment points for a user to affix a variety of devices. A system for natural body interaction for mixed or virtual reality applications, comprising a composition server configured to receive input data from a plurality of hardware devices via a network, and configured to operate a virtual control stick, and configured to produce a plurality of operations of the virtual control stick based at least in part on at least a portion of the received input data, and configured to produce a composite data stream based at least in part on at least a portion of the received input data and the virtual control stick operations.

VARIABLE-RESISTANCE EXERCISE MACHINE WITH WIRELESS COMMUNICATION FOR SMART DEVICE CONTROL AND INTERACTIVE SOFTWARE APPLICATIONS

5 CROSS-REFERENCE TO RELATED APPLICATIONS

[001] This present application is a PCT of and claims priority to United States application serial number 15/219,115 titled, "VARIABLE-RESISTANCE EXERCISE MACHINE WITH WIRELESS COMMUNICATION FOR SMART DEVICE CONTROL AND VIRTUAL REALITY APPLICATIONS" filed July 25, 2016, which claims the benefit of and
10 priority to United States provisional patent application serial number 62/330,642, titled "VARIABLE-RESISTANCE EXERCISE MACHINE WITH WIRELESS COMMUNICATION FOR SMART DEVICE CONTROL AND VIRTUAL REALITY APPLICATIONS", and filed on May 2, 2016, and also is a continuation-in-part of United States patent application serial number 15/193,112, titled "NATURAL BODY
15 INTERACTION FOR MIXED OR VIRTUAL REALITY APPLICATIONS", and filed on June 27, 2016, which claims the benefit of and priority to United States provisional patent application serial number 62/330,602, titled "NATURAL BODY INTERACTION FOR MIXED OR VIRTUAL REALITY APPLICATIONS", and filed on May 2, 2016, the entire specification of each of which is incorporated herein by reference in its entirety.

20 BACKGROUND OF THE INVENTION

Field of the Art

[002] The disclosure relates to the field of exercise equipment, and more particularly to the field of exercise machines for fitness and health.

Discussion of the State of the Art

25 [003] Users often interact with fitness devices such as treadmills or elliptical trainers while using a smart device such as their smartphone or tablet, generally for consuming media. Generally, the interactions with the fitness device and smart device are separate, with media playback occurring independently of the user's operation of an exercise machine. For example, while running on a treadmill a user may choose to view a static screen displaying a
30 television show. The elements in a television show are static, in that the elements do not

change behavior based on the user's interactions with the television show, but instead perform predetermined actions. An example of a dynamic screen is that of a video game. The user interacts with a remote and influences the activity of the elements in the video game. At most, the user may interact with the screen performing an activity independent of actions related to interacting with the fitness device.

[004] In the field of electronic devices, separate handheld controllers are commonly used to enable a user to provide interaction or receive feedback from a host device, such as a personal computer or a video gaming console. These controllers may be connected via a wired or a wireless connection, and generally are paired with only a single host device at any given time. When a user wishes to utilize multiple controllers, they must be connected individually to the host device (for example, connecting both a keyboard and a mouse to a personal computer, using two separate ports on the computer). This requires a number of separate communication connections between a host device and controllers, and if a host device or controller have mismatched communication hardware, they are incompatible and cannot be used. Additionally, controllers generally are designed for a particular purpose (such as for a particular type of video game or computer application), and require a user to interact with them in a specific fashion, such as to hold the controller in a particular manner to have manual access to all of its functions. This can be awkward or even unhealthy for the user, and restrictive of the manner with which they interact with the device.

[005] Additionally, users typically interact with a fitness device, whether viewing or not viewing a static screen. For example, while running on a treadmill a user may choose to view a static screen displaying a television show. The elements in a television show are static, in that the elements do not change behavior based on the user's interactions with the television show, but instead perform predetermined actions. An example of a dynamic screen is that of a video game. The user interacts with a remote and influences the activity of the elements in the video game. At most, the user may interact with the screen performing an activity independent of actions related to interacting with the fitness device.

[006] Furthermore, with the rapidly-expanding virtual reality industry, new interaction methods are being explored including a variety of controllers for gaming, wands, and motion-based input devices including gloves and camera-based hand tracking. However, these devices all focus on interacting with a user's hands and head movements, and ignore other parts of the body that could be used to improve interaction and immersion particularly while

a user is within a known defined environment such as an exercise machine, while also expanding the possibilities for data collection.

[007] What is needed, is an exercise machine that is designed to connect to a variety of user smart devices for interaction, that receives direction from a connected smart device and provides interaction input to a connected smart device, and that provides for the use of the human body as an input method through position and movement tracking.

SUMMARY OF THE INVENTION

[008] Accordingly, the inventor has conceived and reduced to practice, in a preferred embodiment of the invention, a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications.

[009] Accordingly, the inventor has conceived and reduced to practice, in a preferred embodiment of the invention, a system and method for natural body interaction for mixed or virtual reality applications, wherein a user may utilize their body as an input device similar to a joystick or other control interface.

[010] The invention discloses a new, unique exercise machine design that incorporates the best features of conventional treadmills and elliptical machines without the typical compromises. For example, users will be able to walk or run at their own speeds, not based on a specific user-input speed required by all digitally-controlled treadmills. It also provides variable resistance settings to simulate more strenuous walks or climbs. Additionally, the exercise machine of the invention is specifically designed to support various forms of “active” virtual, augmented, or mixed-reality gaming and software application, as well as normal cardio exercises.

[011] According to a preferred embodiment of the invention, a system for natural body interaction for mixed or virtual reality applications, comprising a composition server comprising at least a plurality of programming instructions stored in a memory and operating on a processor of a network-connected computing device and configured to receive input data from a plurality of hardware devices via a network, and configured to operate a virtual control stick, and configured to produce a plurality of operations of the virtual control stick based at least in part on at least a portion of the received input data, and configured to produce a composite data stream based at least in part on at least a portion of the received input data and the virtual control stick operations, is disclosed.

[012] According to another preferred embodiment of the invention, a method for natural body interaction for mixed or virtual reality applications, comprising the steps of: receiving, at a composition server comprising at least a plurality of programming instructions stored in a memory and operating on a processor of a network-connected computing device and
5 configured to receive input data from a plurality of hardware devices via a network, and configured to operate a virtual control stick, and configured to produce a plurality of operations of the virtual control stick based at least in part on at least a portion of the received input data, and configured to produce a composite data stream based at least in part on at least a portion of the received input data and the virtual control stick operations, a plurality of
10 device inputs; creating a virtual control stick software device; and directing the operation of the virtual control stick based at least in part on at least a portion of the device inputs, is disclosed.

[013] According to a preferred embodiment of the invention, a variable-resistance exercise machine with wireless communication for smart device control and interactive software
15 applications as well as other applications such as conventional and virtual reality-based games or therapy/rehabilitation programs, comprising: a wireless network interface configured to communicate with a plurality of user devices via a network, and configured to receive input from a connected user device and configured to provide output to a connected user device; a plurality of moving surfaces each configured to provide an independent degree
20 of resistance to movement, the degree of resistance being based at least in part on received input from a user device, and configured to detect movement and provide output to a user device, the output being based at least in part on the detected movement; and a plurality of rigid rails configured to provide a rigid support for a human user to grasp during movement, and configured to provide a plurality of immovable attachment points for a user to affix a
25 variety of external user devices, is disclosed.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[014] The accompanying drawings illustrate several embodiments of the invention and, together with the description, serve to explain the principles of the invention according to the embodiments. It will be appreciated by one skilled in the art that the particular embodiments
30 illustrated in the drawings are merely exemplary, and are not to be considered as limiting of the scope of the invention or the claims herein in any way.

[015] **Fig. 1** is a side view of a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications, according to a preferred embodiment of the invention.

5 [016] **Fig. 2** is a top-down view of a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications, according to a preferred embodiment of the invention.

[017] **Fig. 3** is a diagram illustrating an exemplary method for interacting with a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications using a smart device, illustrating the use of a plurality of
10 connected smart devices and tethers, and showing interaction via the user's body as a control stick.

[018] **Fig. 4** is a block diagram illustrating an exemplary hardware architecture of a computing device used in an embodiment of the invention.

15 [019] **Fig. 5** is a block diagram illustrating an exemplary logical architecture for a client device, according to an embodiment of the invention.

[020] **Fig. 6** is a block diagram showing an exemplary architectural arrangement of clients, servers, and external services, according to an embodiment of the invention.

[021] **Fig. 7** is another block diagram illustrating an exemplary hardware architecture of a computing device used in various embodiments of the invention.

20 [022] **Fig. 8** is a diagram of an exemplary hardware arrangement of an apparatus for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of multiple tethers and a movable torso harness.

[023] **Fig. 9** is a diagram illustrating a variety of alternate tether arrangements.

25 [024] **Fig. 10** is a diagram of an additional exemplary hardware arrangement of an apparatus for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of angle sensors to detect angled movement of tethers.

30 [025] **Fig. 11** is a diagram illustrating an exemplary hardware arrangement of an apparatus for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of multiple tethers and a movable torso harness comprising a plurality of angle sensors positioned within the movable torso harness.

[026] **Fig. 12** is a diagram of a further arrangement of a system for natural body interaction for mixed or virtual reality applications, illustrating the use of handheld controllers and a headset on an elliptical machine, according to a preferred embodiment of the invention.

[027] **Fig. 13** is a flow diagram illustrating an exemplary method for natural body interaction for mixed or virtual reality applications, according to a preferred embodiment of the invention.

[028] **Fig. 14** is a flow diagram illustrating an exemplary method for processing natural body interaction and additional inputs and producing a composite output, according to a preferred embodiment of the invention.

[029] **Fig. 15** is a block diagram of an exemplary system architecture for natural body interaction for mixed or virtual reality applications, according to a preferred embodiment of the invention.

DETAILED DESCRIPTION

[030] The inventor has conceived, and reduced to practice, in a preferred embodiment of the invention, a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications.

[031] One or more different inventions may be described in the present application. Further, for one or more of the inventions described herein, numerous alternative embodiments may be described; it should be appreciated that these are presented for illustrative purposes only and are not limiting of the inventions contained herein or the claims presented herein in any way. One or more of the inventions may be widely applicable to numerous embodiments, as may be readily apparent from the disclosure. In general, embodiments are described in sufficient detail to enable those skilled in the art to practice one or more of the inventions, and it should be appreciated that other embodiments may be utilized and that structural, logical, software, electrical and other changes may be made without departing from the scope of the particular inventions. Accordingly, one skilled in the art will recognize that one or more of the inventions may be practiced with various modifications and alterations. Particular features of one or more of the inventions described herein may be described with reference to one or more particular embodiments or figures that form a part of the present disclosure, and in which are shown, by way of illustration, specific embodiments of one or more of the inventions. It should be appreciated, however, that such features are not limited to usage in

the one or more particular embodiments or figures with reference to which they are described. The present disclosure is neither a literal description of all embodiments of one or more of the inventions nor a listing of features of one or more of the inventions that must be present in all embodiments.

5 **[032]** Headings of sections provided in this patent application and the title of this patent application are for convenience only, and are not to be taken as limiting the disclosure in any way.

10 **[033]** Devices that are in communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices that are in communication with each other may communicate directly or indirectly through one or more communication means or intermediaries, logical or physical.

15 **[034]** A description of an embodiment with several components in communication with each other does not imply that all such components are required. To the contrary, a variety of optional components may be described to illustrate a wide variety of possible embodiments of one or more of the inventions and in order to more fully illustrate one or more aspects of the inventions. Similarly, although process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may generally be configured to work in alternate orders, unless specifically stated to the contrary. In other words, any sequence or order of steps that may be described in this patent application does not, in and of itself, indicate a requirement that the steps be performed in that order. The steps of described processes may be performed in any order practical. Further, some steps may be performed simultaneously despite being described or implied as occurring non-simultaneously (e.g., because one step is described after the other step). Moreover, the illustration of a process by its depiction in a drawing does not imply that the illustrated process is exclusive of other variations and modifications thereto, does not imply that the illustrated process or any of its steps are necessary to one or more of the invention(s), and does not imply that the illustrated process is preferred. Also, steps are generally described once per embodiment, but this does not mean they must occur once, or that they may only occur once each time a process, method, or algorithm is carried out or executed. Some steps may be omitted in some embodiments or some occurrences, or some steps may be executed more than once in a given embodiment or occurrence.

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[035] When a single device or article is described herein, it will be readily apparent that more than one device or article may be used in place of a single device or article. Similarly, where more than one device or article is described herein, it will be readily apparent that a single device or article may be used in place of the more than one device or article.

5 [036] The functionality or the features of a device may be alternatively embodied by one or more other devices that are not explicitly described as having such functionality or features. Thus, other embodiments of one or more of the inventions need not include the device itself.

[037] Techniques and mechanisms described or referenced herein will sometimes be described in singular form for clarity. However, it should be appreciated that particular
10 embodiments may include multiple iterations of a technique or multiple instantiations of a mechanism unless noted otherwise. Process descriptions or blocks in figures should be understood as representing modules, segments, or portions of code which include one or more executable instructions for implementing specific logical functions or steps in the process. Alternate implementations are included within the scope of embodiments of the
15 present invention in which, for example, functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those having ordinary skill in the art.

Detailed Description of Exemplary Embodiments

[038] **Fig. 1** is a side view of a variable-resistance exercise machine with wireless
20 communication for smart device control and interactive software applications **100**, according to a preferred embodiment of the invention. According to the embodiment, an exercise machine **100** may have a stable base **101** to provide a platform for a user to safely stand or move about upon. Additional safety may be provided through the use of a plurality of integrally-formed or detachable side rails **102**, for example having safety rails on the left and
25 right sides (with respect to a user's point of view) of exercise machine **100** to provide a stable surface for a user to grasp as needed. Additionally, side rails **102** may comprise a plurality of open regions **105a-n** formed to provide additional locations for a user to grasp or for the attachment of additional equipment such as a user's smart device (not shown) through the use of a mountable or clamping case or mount. Formed or removable supports **106a-n** may be
30 used for additional grip or mounting locations, for example to affix a plurality of tethers (not shown) for use in interaction with software applications while a user is using exercise machine **100** (as described below, referring to **Fig. 3**).

[039] Exercise machine **100** may further comprise a rigid handlebar **103** affixed or integrally-formed on one end of exercise machine **100**, for a user to hold onto while facing forward during use. Handlebar **103** may further comprise a stand or mount **104** for a user's smart device such as (for example) a smartphone or tablet computer, so they may safely support and stow the device during use while keeping it readily accessible for interaction (for example, to configure or interact with a software application they are using, or to select different applications, or to control media playback during use, or other various uses).

Handlebar **103** may be used to provide a stable handle for a user to hold onto during use for safety or stability, as well as providing a rigid point for the user to "push off" during use as needed, for example to begin using a moving treadmill surface (described below in **Fig. 2**). During use, a user may also face away from handlebar **103**, using exercise machine **100** in the reverse without their view or range of motion being obscured or obstructed by handlebar **103** (for example, for use with a virtual reality game that requires a wide degree of movement from the user's hands for interaction).

[040] As illustrated, the base **101** of exercise machine **100** may be formed with a mild, symmetrical curvature, to better approximate the natural range of movement of a user's body during use. Common exercise machines such as treadmills generally employ a flat surface, which can be uncomfortable during prolonged or vigorous use, and may cause complications with multi-directional movement or interaction while a user's view is obscured, as with a headset (described below in **Fig. 3**). By incorporating a gradual curvature, a user's movements may feel more natural and require less reorientation or accommodation to become fluid and proficient, and stress to the body may be reduced.

[041] **Fig. 2** is a top-down view of a variable-resistance exercise machine **100** with wireless communication for smart device control and interactive software applications, according to a preferred embodiment of the invention. According to the embodiment, exercise machine **100** may comprise a stable base **101** to provide a platform for a user to safely stand or move about upon. Exercise machine **100** may further comprise right **201a** and left **201b** hand rails for a user to brace against or grip during use, to provide a stable support for safety as well as a mounting point for external devices such as a plurality of tethers, as described below with reference to **Fig. 3**. A plurality of steps **202a-n** may be used to provide a user with a safe and easy means to approach or dismount exercise machine **100**, as well as a nonmoving "staging area" where a user may stand while they configure operation or wait for exercise machine **100** to start operation. Unlike traditional treadmill machines common in the art, exercise

machine **100** may be made with greater width to accommodate a wider range of free movement of a user's entire body (whereas traditional treadmills are designed to best accommodate only a jogging or running posture, with minimal lateral motion), and a plurality of separate moving surfaces **203a-b** may be utilized to provide multiple separate surfaces that may move and be controlled independently of one another during use. For example, a user may move each of their legs independently without resistance applied, with separate moving surfaces **203a-b** moving freely underfoot as a user applies pressure during their movement. This may provide the illusion of movement to a user while in reality they remain stationary with respect to their surroundings. Another use may be multiple separate moving surfaces **203a-b**, with separate speeds of movement or degrees of resistance, so that as a user moves about during use they may experience physical feedback in the form of changing speed or resistance, indicating where they are standing or in what direction they are moving (for example, to orient a user wearing a virtual reality headset, as described below with reference to **Fig. 3**). Moving surfaces **203a-b** may be formed with a texture **204** to increase traction, which may improve user safety and stability during use as well as improve the operation of moving surfaces **203a-b** for use in multidirectional movement (as the user's foot is less likely to slide across a surface rather than taking purchase and applying directional pressure to produce movement). Use of multiple, multidirectional moving surfaces **203a-b** may also be used in various therapeutic or rehabilitation roles, for example to aid a user in developing balance or range of motion. For example, a user who is recovering from an injury or surgery (such as a joint repair or replacement surgery) may require regular physical therapy during recovery. Use of multidirectional moving surfaces **203a-b** along with appropriate guidance from a rehabilitation specialist or physical therapist (or optionally a virtual or remote coach using a software application) may make regular therapy more convenient and accessible to the user, rather than requiring in-home care or regular visits to a clinic. For example, by enabling a therapist or coach to manually vary the movement and resistance of the moving surfaces **203a-b**, they can examine a user's ability to overcome resistance to different movements such as at odd angles or across varying range of motion, to examine the user's physical health or ability. By further varying the resistance it becomes possible to assist the user with rehabilitation by providing targeted resistance training to specific movements, positions, or muscle groups to assist in recovery and development of the user's abilities.

[042] Exercise machine **100** may be designed without a control interface commonly utilized by exercise machines in the art, instead being configured with any of a variety of wireless

network interfaces such as WiFi or BLUETOOTH™ for connection to a user's smart device, such as a smartphone or tablet computer. When connected, a user may use a software application on their device to configure or direct the operation of exercise machine **100**, for example by manually configuring a variety of operation settings such as speed or resistance, or by interacting with a software application that automatically directs the operation of exercise machine **100** without exposing the particular details of operation to a user.

Additionally, communication may be bi-directional, with a smart device directing the operation of exercise machine **100** and with exercise machine **100** providing input to a smart device based at least in part on a user's activity or interaction. For example, a user may interact with a game on their smart device, which directs the operation of exercise machine **100** during play as a form of interaction with, and feedback to, the user. For example, in a racing game, exercise machine **100** may alter the resistance of moving surfaces **203a-b** as a user's speed changes within the game. In another example, a user may be moving about on moving surfaces **203a-b** while playing a simulation or roleplaying game, and their movement may be provided to the connected smart device for use in controlling an in-game character's movement. Another example may be two-way interactive media control, wherein a user may select media such as music for listening on their smart device, and then while using exercise machine **100** their level of exertion (for example, the speed at which they run or jog) may be used to provide input to their smart device for controlling the playback of media. For example, if the user slows down music may be played slowly, distorting the audio unless the user increases their pace. In this manner, exercise machine **100** may be used interchangeably as a control and feedback device or both simultaneously, providing an immersive environment for a wide variety of software applications such as virtual reality, video games, fitness and health applications, or interactive media consumption.

[043] **Fig. 3** is a diagram illustrating an exemplary method for interacting with a variable-resistance exercise machine **100** with wireless communication for smart device control and interactive software applications using a smart device, illustrating the use of a plurality of connected smart devices and tethers, and showing interaction via the user's body as a control stick (referencing 9407?). According to the embodiment, a user **301** may be standing, walking, or running on a variable-resistance exercise machine **100** with wireless communication for smart device control and virtual reality applications with a stable base **101** and two separate moveable surfaces **203a**, **203b** for separate movement of the user's legs. Exercise machine **100** may have fixed handlebars with affixed or integrally-formed

controllers **305a**, **305b** for use as connected smart devices for interaction, and support rails **201a**, **201b** for a user to hold onto or affix tethers for safety or interaction when needed. User **401** may interact with software applications using a variety of means, including manual interaction via controller devices **305a**, **305b** that may be held in the hand for example to use
5 as motion-input control devices (such as GOJI PLAY™ controllers, for example—which were disclosed in parent application 14/012,879) or (as illustrated) may be affixed or integrally-formed into exercise machine **100**. This may provide a user with traditional means of interacting with software applications while using exercise machine **100**. Additionally, a user's body position or movement may be tracked and used as input, for example via a
10 plurality of tethers **304a-n** affixed to handlebars **201a**, **201b** and a belt, harness or saddle **303** worn by user **301**, or using a headset device **302** that may track the position or movement of a user's head as well as provide video (and optionally audio) output to the user, such as a virtual reality headset that displays images while blocking the user's view of the outside world, or an augmented reality or mixed reality headset that combines presented information
15 with the user's view using transparent or semitransparent displays (for example, using transparent OLED displays, hologram displays, projected displays, or other various forms of overlaying a display within a user's normal field of vision without obstructing the user's view). Body tracking may be used to recognize additional input data from user **301** (in addition to manual input via controllers **305a**, **305b**), by tracking the position and movement
20 of user **301** during use. For example, motion tracking within a headset device **302** may be used to recognize a variety of translational **310** or rotational **320** movement of user's **301** head, such as leaning to the side, or looking over the shoulder. Tethers **304a-n** may recognize a variety of movement of user's **301** torso, such as leaning, crouching, sidestepping, or other body movement. This body tracking may then be utilized either as feedback to rehab
25 programs (for example, to track a user's posture for physical therapy coaching or exercises such as holding yoga poses) or input similar to a control stick or joystick in manual controller arrangements, for example by interpreting the user's entire body as the "stick" and processing their body movements as if they were stick movements done manually (such as to control in-game character posture or movement, or to direct movement in certain applications such as
30 vehicle simulations that may turn or accelerate in response to stick movements).

[044] For example, a user **301** on exercise machine **100** may be playing a virtual reality skiing game or rehab program wherein they are given audio and video output via a headset **302** to immerse them in a virtual ski resort. When user **301** is not skiing, they may be able to

use manual controls **305a**, **305b** for such operations as selecting from an on-screen menu, or typing text input such as to input their name or to chat with other players using text. When they begin skiing within the game, user **301** may be instructed in proper ski posture or technique, and may then use their body to control various aspects of their virtual skiing, such as leaning to the side **320** to alter their course and avoid trees or other skiers, or jumping **310** to clear rocks or gaps. Movement of their head may be detected by a headset **302** and used to control their view independently of their body as it is tracked by tethers **304a-n**, allowing user **301** to look around freely without interfering with their other controls. In this manner, the user's entire body may serve as an input control device for the game, allowing and encouraging them to use natural body movements to control their gameplay in an immersive manner while still retaining the option to use more familiar manual control means as needed. Alternatively, specific body functions such as hip twisting are used as user feedback for rehabilitating programs, including rehab games.

[045] **Fig. 8** is a diagram of an exemplary hardware arrangement **800** for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of multiple tethers **810a-n** and a movable torso harness **820**. According to the embodiment, a plurality of tethers **810a-n** may be affixed or integrally-formed as part of a handle or railing **830**, such as handlebars found on exercise equipment such as a treadmill, elliptical trainer, stair-climbing machine, or the like. In alternate arrangements, specifically-designed equipment with integral tethers **810a-n** may be used, but it may be appreciated that a modular design with tethers **810a-n** that may be affixed and removed freely may be desirable for facilitating use with a variety of fitness equipment or structural elements of a building, according to a user's particular use case or circumstance. Tethers **810a-n** may then be affixed or integrally-formed to a torso harness **820**, as illustrated in the form of a belt, that may be worn by a user such that movement of their body affects tethers **810a-n** and applies stress to them in a variety of manners. It should be appreciated that while a belt design for a torso harness **820** is shown for clarity, a variety of physical arrangements may be used such as including (but not limited to) a vest, a series of harness-like straps similar to climbing or rappelling equipment, a backpack, straps designed to be worn on a user's body underneath or in place of clothing (for example, for use in medical settings for collecting precise data) or a plurality of specially-formed clips or attachment points that may be readily affixed to a user's clothing. Additionally, a torso harness **820** may be constructed with movable parts, for example having an inner belt **821** that permits a user

some degree of motion within the harness **820** without restricting their movement. Movement of inner belt **821** (or other movable portions) may be measured in a variety of ways, such as using accelerometers, gyroscopes, or optical sensors, and this data may be used as interaction with software applications in addition to data collected from tethers **810a-n** as described
5 below. In some embodiments, a saddle-like surface on which a user may sit may be used, with motion of the saddle-like surface measured as described generally herein.

[046] As a user moves, his or her body naturally shifts position and orientation. These shifts may be detected and measured via tethers **810a-n**, for example by detecting patterns of tension or strain on tethers **810a-n** to indicate body orientation, or by measuring small
10 changes in strain on tethers **810a-n** to determine more precise movements such as body posture while a user is speaking, or specific characteristics of a user's stride or gait.

Additionally, through varying the quantity and arrangement of tethers **810a-n**, more precise or specialized forms of movement may be detected and measured (such as, for example, using a specific arrangement of multiple tethers connected to a particular area of a user's
15 body to detect extremely small movements for medical diagnosis or fitness coaching). This data may be used as interaction with software applications, such as for virtual reality applications as input for a user to control a character in a game. In such an arrangement, when a user moves, this movement may be translated to an in-game character or avatar to convey a more natural sense of interaction and presence. For example, in a multiplayer
20 roleplaying game, this may be used to facilitate nonverbal communication and recognition between players, as their distinct mannerisms and gestures may be conveyed in the game through detection of natural torso position and movement. In fitness or health applications, this data may be used to track and monitor a user's posture or ergonomic qualities, or to assist in coaching them for specific fitness activities such as holding a pose for yoga, stretching, or
25 proper running form during use with a treadmill. In medical applications, this data may be used to assist in diagnosing injuries or deficiencies that may require attention, such as by detecting anomalies in movement or physiological adaptations to an unrecognized injury (such as when a user subconsciously shifts their weight off an injured foot or knee, without consciously realizing an issue is present).

[047] Through various arrangements of tethers **810a-n** and tether sensors (as described below, referring to **Figs. 9-11**), it may be possible to enable a variety of immersive ways for a user to interact with software applications, as well as to receive haptic feedback from applications. For example, by detecting rotation, tension, stress, or angle of tethers a user may

interact with applications such as virtual reality games or simulations, by using natural body movements and positioning such as leaning, jumping, crouching, kneeling, turning, or shifting their weight in various directions to trigger actions within a software application configured to accept torso tracking input. By applying haptic feedback of varying form and intensity (as is described in greater detail below, referring to **Fig. 9**), applications may provide physical indication to a user of software events, such as applying tension to resist movement, pulling or tugging on a tether to move or “jerk” a user in a direction, or varying feedback to multiple tethers such as tugging and releasing in varying order or sequence to simulate more complex effects such as (for example, in a gaming use case) explosions, riding in a vehicle, or walking through foliage.

[048] It should be appreciated that while reference is made to virtual reality applications, a wide variety of use cases may be possible according to the embodiment. For example, torso tracking may be used for fitness and health applications, to monitor a user’s posture or gait while walking, without the use of additional virtual reality equipment or software.

[049] **Fig. 9** is a diagram illustrating a variety of alternate tether arrangements. According to various use cases and hardware arrangements, tethers **810a-n** may utilize a variety of purpose-driven designs as illustrated. For example, a “stretchable” tether **910** may be used to measure strain during a user’s movement, as the tether **910** is stretched or compressed (for example, using piezoelectric materials and measuring electrical changes). Such an arrangement may be suitable for precise measurements, but may lack the mechanical strength or durability for gross movement detection or prolonged use. An alternate construction may utilize a non-deforming tether **920** such as a steel cable or similar non-stretching material. Instead of measuring strain on the tether **920**, instead tether **920** may be permitted a degree of movement within an enclosure **922** (for example, an attachment point on a torso harness **820** or handlebar **830**), and the position or movement **921** of the tether **920** may be measured such as via optical sensors. In a third exemplary arrangement, a tether **930** may be wound about an axle or pulley **931**, and may be let out when force is applied during a user’s movement. Rotation of the pulley **931** may be measured, or alternately a tension device such as a coil spring may be utilized (not shown) and the tension or strain on that device may be measured as tether **930** is extended or retracted. In this manner, it may be appreciated that a variety of mechanical means may be used to facilitate tethers and attachments for use in detecting and measuring natural torso position and movement, and it should be appreciated that a variety of

additional or alternate hardware arrangements may be utilized according to the embodiments disclosed herein.

[050] Additionally, through the use of various hardware construction it becomes possible to utilize both “passive” tethers that merely measure movement or strain, as well as “active” tethers that may apply resistance or movement to provide haptic feedback to a user. For example, in an arrangement utilizing a coiled spring or pulley **931**, the spring or pulley **931** may be wound to retract a tether and direct or impede a user’s movement as desired. In this manner, various new forms of feedback-based interaction become possible, and in virtual reality use cases user engagement and immersion are increased through more natural physical feedback during their interaction.

[051] By applying various forms and intensities of feedback using various tether arrangements, a variety of feedback types may be used to provide haptic output to a user in response to software events. For example, tension on a tether may be used to simulate restrained movement such as wading through water or dense foliage, walking up an inclined surface, magnetic or gravitational forces, or other forms of physical resistance or impedance that may be simulated through directional or non-directional tension. Tugging, retracting, or pulling on a tether may be used to simulate sudden forces such as recoil from gunfire, explosions, being grabbed or struck by a software entity such as an object or character, deploying a parachute, bungee jumping, sliding or falling, or other momentary forces or events that may be conveyed with a tugging or pulling sensation. By utilizing various patterns of haptic feedback, more complex events may be communicated to a user, such as riding on horseback or in a vehicle, standing on the deck of a ship at sea, turbulence in an aircraft, weather, or other virtual events that may be represented using haptic feedback. In this manner, virtual environments and events may be made more immersive and tangible for a user, both by enabling a user to interact using natural body movements and positioning, as well as by providing haptic feedback in a manner that feels natural and expected to the user. For example, if a user is controlling a character in a gaming application through a first-person viewpoint, it would seem natural that when their character is struck there would be a physical sensation corresponding to the event; however, this is not possible with traditional interaction devices, detracting from any sense of immersion or realism for the user. By providing this physical sensation alongside the virtual event, the experience becomes more engaging and users are encouraged to interact more naturally as their actions results in natural and believable feedback, meeting their subconscious expectations and avoiding excessive

“immersion-breaking” moments, which in turn reduces the likelihood of users adopting unusual behaviors or unhealthy posture as a result of adapting to limited interaction schema.

[052] Haptic feedback may be provided to notify a user of non-gaming events, such as for desktop notifications for email or application updates, or to provide feedback on their posture for use in fitness or health coaching. For example, a user may be encouraged to maintain a particular stance, pose, or posture while working or for a set length of time (for example, for a yoga exercise application), and if their posture deviates from an acceptable range, feedback is provided to remind them to adjust their posture. This may be used in sports, fitness, health, or ergonomic applications that need not utilize other aspects of virtual reality and may operate as traditional software applications on nonspecialized computing hardware. For example, a user at their desk may use an ergonomic training application that monitors their body posture throughout the work day and provides haptic reminders to correct poor posture as it is detected, helping the user to maintain a healthy working posture to reduce fatigue or injuries due to poor posture (for example, repetitive-stress injuries that may be linked to poor posture while working at a computer).

[053] **Fig. 10** is a diagram of an additional exemplary hardware arrangement **1000** for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of angle sensors **1012, 1021a-n** to detect angled movement of a tether **1020**. According to one exemplary arrangement, a tether **1010** may be affixed to or passed through a rotating joint such as a ball bearing **1011** or similar, to permit free angular movement. During movement, the angular movement or deflection **1012** of a protruding bar, rod, or tether segment **1013** may be measured (for example, using optical, magnetic, or other sensors) to determine the corresponding angle of tether **1010**. In this manner, precise angle measurements may be collected without impeding range of motion or introducing unnecessary mechanical complexity.

[054] In an alternate hardware arrangement, the use of angle sensors **1021a-n** enables tracking of a vertical angle of a tether **1020**, to detect and optionally measure vertical movement or orientation of a user's torso. When tether **1020** contacts a sensor **1021a-n**, this may be registered and used to detect a general vertical movement (that is, whether the tether is angled up or down). For more precise measurements, the specific hardware construction of a sensor **1021a-n** may be varied, for example using a pressure-sensing switch to detect how much force is applied and use this measurement to determine the corresponding angle (as may be possible given a tether **1020** of known construction). It should be appreciated that

various combinations of hardware may be used to provide a desired method or degree of angle detection or measurement, for example using a conductive tether **1020** and a capacitive sensor **1021a-n** to detect contact, or using a mechanical or rubber-dome switch (as are commonly used in keyboard construction) to detect physical contact without a conductive tether **1020**.

[055] The use of angle detection or measurement may expand interaction possibilities to encompass more detailed and natural movements of a user's body. For example, if a user crouches, then all tethers **910a-n** may detect a downward angle simultaneously. Additionally, data precision or availability may be enhanced by combining input from multiple available sensors when possible (for example, utilizing adaptive software to collect data from any sensors that it detects, without requiring specific sensor types for operation), for example by combining data from tethers **910a-n** and hardware sensors such as an accelerometer or gyroscope, enabling multiple methods of achieving similar or varied types or precision levels of position or movement detection. Similarly, when a user jumps then all tethers may detect an upward angle simultaneously. However, if a user leans in one direction, it may be appreciated that not all tethers **910a-n** will detect the same angle. For example, tethers **910a-n** in the direction the user is leaning may detect a downward angle, while those on the opposite side would detect an upward angle (due to the orientation of the user's torso and thus a worn torso harness **920**). In this manner, more precise torso interaction may be facilitated through improved detection and recognition of orientation and movement. Additionally, it may be appreciated that sensors **1021a-n** may be utilized for other angle measurements, such as to detect horizontal angle. For example, if a user is wearing a non-rotating torso harness **920**, when they twist their body a similar stress may be applied to all attached tethers **910a-n**. Without angle detection the precise nature of this movement will be vague, but with horizontal angle detection it becomes possible to recognize that all tethers **910a-n** are being strained in a similar direction (for example, in a clockwise pattern when viewed from above, as a user might view tethers **910a-n** during use), and therefore interpret the interaction as a twisting motion (rather than, for example, a user squatting or kneeling, which might apply a similar stress to the tethers **910a-n** but would have different angle measurements).

[056] **Fig. 11** is a diagram illustrating an exemplary hardware arrangement of an apparatus for natural torso tracking and feedback for electronic interaction according to a preferred embodiment of the invention, illustrating the use of multiple tethers **810a-n** and a movable

torso harness **820** comprising a plurality of angle sensors **1101a-n** positioned within the movable torso harness **820**. According to the embodiment, a plurality of tethers **810a-n** may be affixed or integrally-formed as part of a handle or railing **830**, such as handlebars found on exercise equipment such as a treadmill, elliptical trainer, stair-climbing machine, or the like.

5 In alternate arrangements, specifically-designed equipment with affixed or integral tethers **810a-n** may be used, but it may be appreciated that a modular design with tethers **810a-n** that may be affixed and removed freely may be desirable for facilitating use with a variety of fitness equipment or structural elements of a building, according to a user's particular use case or circumstance as well as weight-holding strength of the tethers. Tethers **810a-n** may then be affixed or integrally-formed to angle sensors **1101a-n** placed within or integrally-formed as a component of torso harness **820** (as illustrated in the form of a belt) that may be worn by a user such that movement of their body affects tethers **810a-n** and applies detectable or measurable stress to tethers **810a-n** and angular motion to angle sensors **1101a-n**. In this manner, it may be appreciated that angle sensors **1101a-n** may be utilized as integral or removable components of a torso harness **820**, as an alternative arrangement to utilizing angle sensors **1101a-n** placed or formed within railings **830** or other equipment components connected to distal ends of tethers **810a-n** (with respect to the user's torso). According to various embodiments, sensors may be placed optionally on a belt, harness, or saddle-like surface or at attachment points on safety railings, or indeed both.

20 [057] **Fig. 12** is a diagram of a further arrangement of a system **1200** for natural body interaction for mixed or virtual reality applications, illustrating the use of fixed controllers **1203a-b** and a headset **1204** on an elliptical machine **1202**, according to a preferred embodiment of the invention. According to the embodiment, a user **1201** may use an elliptical trainer **1202** or similar fitness device while using a headset device **1204** for mixed or virtual reality interaction. During operation, user **1201** may interact manually with controller **1203a-b** affixed to or integrally formed as a portion of the elliptical trainer **1202**, and may also interact through position or movement tracking provided by headset **1204** for natural body tracking. For example, a user **1201** may use an elliptical trainer **1202** while playing a virtual reality flight simulation game that places the user inside the cockpit of a plane during flight. User **1201** may use fixed controls **1203a-b** to operate various aircraft controls within the game, which may feel natural as these would generally be in a fixed position relative to a seated pilot. For flying the virtual aircraft, the user may tilt **1205** and move their head, providing body tracking data via headset **1204**, such as through onboard

position or motion sensing hardware, for example a gyroscope, accelerometer, or optical tracking device. Feedback may be provided to the user in the form of exercise resistance, increasing or decreasing the difficulty of operating the elliptical machine **1202** in response to events in the game or software application (for example, increasing resistance as the aircraft gains altitude in a flight simulation game, or increasing resistance as a part of increasing difficulty in a game). In this manner, the user may easily enjoy natural body input for mixed or virtual reality applications, with minimal hardware or environment setup allowing them to utilize the enhanced input functions with a variety of existing equipment, devices, or environments as desired.

[058] Additionally, it may be appreciated that the specific arrangement or configuration of hardware devices in use may vary, for example omitting tethers (as described above, in **Fig. 3**) according to the nature of a fitness device **1202** or environment where interaction is taking place. For example, a user may use a headset **1204** to engage in body tracking for mixed or virtual reality applications using any available fitness device **1202**, for example to enhance their exercise at a gym where they may use any available devices and may change devices multiple times during use. In other arrangements, a user may utilize an open space such as an empty room or workspace (such as an alcove intended for a desk or cubicle), and may setup their devices in this space according to its size or layout. For example, multiple tethers may be used by affixing to walls or furniture within a reasonable distance, utilizing existing room features in place of a fitness device or exercise machine as desired.

[059] Additionally, in some arrangements haptic feedback may be provided to further enhance immersion and natural interaction, according to the capabilities of an environment or devices used. For example, if multiple tethers are used, tension or movement may be applied to these tethers as software output, to provide physical feedback for a user during operation.

As an example, a user may setup multiple tethers in an open space as described above, for use in a boxing simulation game. During gameplay, sudden “jerking” tension may be applied to one or more tethers, to simulate a “knock-back” effect from an opponent’s blow, or constant tension may be applied to restrain a user’s movements during grappling. In another example, a user may be playing a virtual reality flight simulator as described previously (referring to **Fig. 12**), and tethers may be used to restrain the user’s movement within the virtual aircraft cockpit by applying tension to “strap them in” as though they were seated and buckled into a pilot’s chair. Additional momentary tension may be utilized to simulate external forces such as G-forces during maneuvers, or impacts to the user’s aircraft.

[060] **Fig. 13** is a flow diagram illustrating an exemplary method **1300** for natural body interaction for mixed or virtual reality applications, according to a preferred embodiment of the invention. In an initial step **1301**, a composition server **1501** (as described previously, referring to **Fig. 15**) may load a variety of device and tracking configuration data, such as

5 preconfigured parameters to establish a “default mode” or baseline tracking behavior, or using historical data from previous sessions if available. Device tracking may optionally be calibrated **1301a** if needed, for example if new devices are detected or an arrangement has changed since previous operation, or if a user manually requests calibration (or any other criteria, such as a configured calibration time interval). Devices may then begin tracking a

10 user’s torso position and movement **1302**, providing these readings to the composition server as input data. In a next step **1303**, composition server **1501** may create a virtual “torso joystick” within a software application, to emulate a standard control stick input device in software without needing a hardware device present. In a next step **1304**, composition server **1501** may translate received torso readings from previous steps into movements of the

15 software-based torso joystick, and in a final step **1305** may provide these torso joystick movements as user input for further use. In this manner, movement of a user’s body may be used to emulate the movements or other behaviors of a control stick, enabling complex and reliable interaction with software applications through natural body movements. By translating these movements into joystick input via composition server **1501**, this

20 functionality may be added to existing software programs and games that have support for control stick interfaces, without the need for additional configuration.

[061] **Fig. 14** is a flow diagram illustrating an exemplary method **1400** for processing natural body interaction and additional inputs and producing a composite output, according to a preferred embodiment of the invention. In an initial step **1401**, a composition server **1501**

25 may receive a plurality of device inputs, such as motion data from a controller **1504** or headset **1503**, or fitness data from a fitness tracking device **1505**, or other device input. In a next step **1402**, composition server **1501** may receive a variety of torso tracking input, such as movement data from a headset **1503** or torso position or movement tracking via a plurality of tethers **308a-b** (as described previously in **Fig. 3**). In a next step **1403**, received data may

30 be compared to calibration values to perform data “clean up”, for example by discarding erroneous readings or by adjusting readings based on known calibration (such as applying an offset to normalize readings), and in a next step **1404** the resulting calibrated readings may be further compared against each other and further refined as necessary (for example, applying

an offset or bias to a portion of readings to normalize them relative to other readings, such as having an “axis multiplier” to correct for distorted movement along a particular axis relative to other axes). In a next step **1405**, these calibrated readings may then be used to derive composite tracking data, such as by utilizing tracking of hands and head to identify complex movements of a user’s hands relative to their face, or by combining head and torso movement to identify more complex poses or movements of the user’s body, such as leaning in one direction while looking in another, or attempting to hold a specific complex pose such as for yoga or contortion-based games. In a final step **1406**, composite data may be provided as user input for further use in software applications, for example for use in a gaming application or for use by a connected computing device such as a personal computer or video game console. In this manner, multiple data type or sources may be used to derive more complex and detailed movements and other data, and this may be combined into a single composite input for use in software applications according to their particular configuration (such as for use in a video games designed to accept control stick input, but not designed or readily adaptable to utilize fitness tracker data).

Hardware Architecture

[062] Generally, the techniques disclosed herein may be implemented on hardware or a combination of software and hardware. For example, they may be implemented in an operating system kernel, in a separate user process, in a library package bound into network applications, on a specially constructed machine, on an application-specific integrated circuit (ASIC), or on a network interface card.

[063] Software/hardware hybrid implementations of at least some of the embodiments disclosed herein may be implemented on a programmable network-resident machine (which should be understood to include intermittently connected network-aware machines) selectively activated or reconfigured by a computer program stored in memory. Such network devices may have multiple network interfaces that may be configured or designed to utilize different types of network communication protocols. A general architecture for some of these machines may be described herein in order to illustrate one or more exemplary means by which a given unit of functionality may be implemented. According to specific embodiments, at least some of the features or functionalities of the various embodiments disclosed herein may be implemented on one or more general-purpose computers associated with one or more networks, such as for example an end-user computer system, a client computer, a network server or other server system, a mobile computing device (e.g., tablet computing device,

mobile phone, smartphone, laptop, or other appropriate computing device), a consumer electronic device, a music player, or any other suitable electronic device, router, switch, or other suitable device, or any combination thereof. In at least some embodiments, at least some of the features or functionalities of the various embodiments disclosed herein may be implemented in one or more virtualized computing environments (e.g., network computing clouds, virtual machines hosted on one or more physical computing machines, or other appropriate virtual environments).

[064] Referring now to **Fig. 4**, there is shown a block diagram depicting an exemplary computing device **10** suitable for implementing at least a portion of the features or functionalities disclosed herein. Computing device **10** may be, for example, any one of the computing machines listed in the previous paragraph, or indeed any other electronic device capable of executing software- or hardware-based instructions according to one or more programs stored in memory. Computing device **10** may be configured to communicate with a plurality of other computing devices, such as clients or servers, over communications networks such as a wide area network a metropolitan area network, a local area network, a wireless network, the Internet, or any other network, using known protocols for such communication, whether wireless or wired.

[065] In one embodiment, computing device **10** includes one or more central processing units (CPU) **12**, one or more interfaces **15**, and one or more busses **14** (such as a peripheral component interconnect (PCI) bus). When acting under the control of appropriate software or firmware, CPU **12** may be responsible for implementing specific functions associated with the functions of a specifically configured computing device or machine. For example, in at least one embodiment, a computing device **10** may be configured or designed to function as a server system utilizing CPU **12**, local memory **11** and/or remote memory **16**, and interface(s) **15**. In at least one embodiment, CPU **12** may be caused to perform one or more of the different types of functions and/or operations under the control of software modules or components, which for example, may include an operating system and any appropriate applications software, drivers, and the like.

[066] CPU **12** may include one or more processors **13** such as, for example, a processor from one of the Intel, ARM, Qualcomm, and AMD families of microprocessors. In some embodiments, processors **13** may include specially designed hardware such as application-specific integrated circuits (ASICs), electrically erasable programmable read-only memories (EEPROMs), field-programmable gate arrays (FPGAs), and so forth, for controlling

operations of computing device **10**. In a specific embodiment, a local memory **11** (such as non-volatile random access memory (RAM) and/or read-only memory (ROM), including for example one or more levels of cached memory) may also form part of CPU **12**. However, there are many different ways in which memory may be coupled to system **10**. Memory **11** may be used for a variety of purposes such as, for example, caching and/or storing data, programming instructions, and the like. It should be further appreciated that CPU **12** may be one of a variety of system-on-a-chip (SOC) type hardware that may include additional hardware such as memory or graphics processing chips, such as a QUALCOMM SNAPDRAGON™ or SAMSUNG EXYNOS™ CPU as are becoming increasingly common in the art, such as for use in mobile devices or integrated devices.

[067] As used herein, the term “processor” is not limited merely to those integrated circuits referred to in the art as a processor, a mobile processor, or a microprocessor, but broadly refers to a microcontroller, a microcomputer, a programmable logic controller, an application-specific integrated circuit, and any other programmable circuit.

[068] In one embodiment, interfaces **15** are provided as network interface cards (NICs). Generally, NICs control the sending and receiving of data packets over a computer network; other types of interfaces **15** may for example support other peripherals used with computing device **10**. Among the interfaces that may be provided are Ethernet interfaces, frame relay interfaces, cable interfaces, DSL interfaces, token ring interfaces, graphics interfaces, and the like. In addition, various types of interfaces may be provided such as, for example, universal serial bus (USB), Serial, Ethernet, FIREWIRE™, THUNDERBOLT™, PCI, parallel, radio frequency (RF), BLUETOOTH™, near-field communications (e.g., using near-field magnetics), 802.11 (WiFi), frame relay, TCP/IP, ISDN, fast Ethernet interfaces, Gigabit Ethernet interfaces, Serial ATA (SATA) or external SATA (ESATA) interfaces, high-definition multimedia interface (HDMI), digital visual interface (DVI), analog or digital audio interfaces, asynchronous transfer mode (ATM) interfaces, high-speed serial interface (HSSI) interfaces, Point of Sale (POS) interfaces, fiber data distributed interfaces (FDDIs), and the like. Generally, such interfaces **15** may include physical ports appropriate for communication with appropriate media. In some cases, they may also include an independent processor (such as a dedicated audio or video processor, as is common in the art for high-fidelity A/V hardware interfaces) and, in some instances, volatile and/or non-volatile memory (e.g., RAM).

[069] Although the system shown in **Fig. 4** illustrates one specific architecture for a computing device **10** for implementing one or more of the inventions described herein, it is by no means the only device architecture on which at least a portion of the features and techniques described herein may be implemented. For example, architectures having one or
5 any number of processors **13** may be used, and such processors **13** may be present in a single device or distributed among any number of devices. In one embodiment, a single processor **13** handles communications as well as routing computations, while in other embodiments a separate dedicated communications processor may be provided. In various embodiments, different types of features or functionalities may be implemented in a system according to the
10 invention that includes a client device (such as a tablet device or smartphone running client software) and server systems (such as a server system described in more detail below).

[070] Regardless of network device configuration, the system of the present invention may employ one or more memories or memory modules (such as, for example, remote memory block **16** and local memory **11**) configured to store data, program instructions for the general-
15 purpose network operations, or other information relating to the functionality of the embodiments described herein (or any combinations of the above). Program instructions may control execution of or comprise an operating system and/or one or more applications, for example. Memory **16** or memories **11, 16** may also be configured to store data structures, configuration data, encryption data, historical system operations information, or any other
20 specific or generic non-program information described herein.

[071] Because such information and program instructions may be employed to implement one or more systems or methods described herein, at least some network device embodiments may include nontransitory machine-readable storage media, which, for example, may be configured or designed to store program instructions, state information, and the like for
25 performing various operations described herein. Examples of such nontransitory machine-readable storage media include, but are not limited to, magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD- ROM disks; magneto-optical media such as optical disks, and hardware devices that are specially configured to store and perform program instructions, such as read-only memory devices (ROM), flash memory (as
30 is common in mobile devices and integrated systems), solid state drives (SSD) and “hybrid SSD” storage drives that may combine physical components of solid state and hard disk drives in a single hardware device (as are becoming increasingly common in the art with regard to personal computers), memristor memory, random access memory (RAM), and the

like. It should be appreciated that such storage means may be integral and non-removable (such as RAM hardware modules that may be soldered onto a motherboard or otherwise integrated into an electronic device), or they may be removable such as swappable flash memory modules (such as “thumb drives” or other removable media designed for rapidly exchanging physical storage devices), “hot-swappable” hard disk drives or solid state drives, removable optical storage discs, or other such removable media, and that such integral and removable storage media may be utilized interchangeably. Examples of program instructions include both object code, such as may be produced by a compiler, machine code, such as may be produced by an assembler or a linker, byte code, such as may be generated by for example a JAVA™ compiler and may be executed using a Java virtual machine or equivalent, or files containing higher level code that may be executed by the computer using an interpreter (for example, scripts written in Python, Perl, Ruby, Groovy, or any other scripting language).

[072] In some embodiments, systems according to the present invention may be implemented on a standalone computing system. Referring now to **Fig. 5**, there is shown a block diagram depicting a typical exemplary architecture of one or more embodiments or components thereof on a standalone computing system. Computing device **20** includes processors **21** that may run software that carry out one or more functions or applications of embodiments of the invention, such as for example a client application **24**. Processors **21** may carry out computing instructions under control of an operating system **22** such as, for example, a version of MICROSOFT WINDOWS™ operating system, APPLE MACOS™ or iOS™ operating systems, some variety of the Linux operating system, ANDROID™ operating system, or the like. In many cases, one or more shared services **23** may be operable in system **20**, and may be useful for providing common services to client applications **24**. Services **23** may for example be WINDOWS™ services, user-space common services in a Linux environment, or any other type of common service architecture used with operating system **21**. Input devices **28** may be of any type suitable for receiving user input, including for example a keyboard, touchscreen, microphone (for example, for voice input), mouse, touchpad, trackball, or any combination thereof. Output devices **27** may be of any type suitable for providing output to one or more users, whether remote or local to system **20**, and may include for example one or more screens for visual output, speakers, printers, or any combination thereof. Memory **25** may be random-access memory having any structure and architecture known in the art, for use by processors **21**, for example to run software. Storage devices **26** may be any magnetic, optical, mechanical, memristor, or electrical storage device

for storage of data in digital form (such as those described above, referring to **Fig. 4**).

Examples of storage devices **26** include flash memory, magnetic hard drive, CD-ROM, and/or the like.

[073] In some embodiments, systems of the present invention may be implemented on a

distributed computing network, such as one having any number of clients and/or servers.

Referring now to **Fig. 6**, there is shown a block diagram depicting an exemplary architecture

30 for implementing at least a portion of a system according to an embodiment of the

invention on a distributed computing network. According to the embodiment, any number of clients **33** may be provided. Each client **33** may run software for implementing client-side

portions of the present invention; clients may comprise a system **20** such as that illustrated in **Fig. 5**. In addition, any number of servers **32** may be provided for handling requests received

from one or more clients **33**. Clients **33** and servers **32** may communicate with one another

via one or more electronic networks **31**, which may be in various embodiments any of the Internet, a wide area network, a mobile telephony network (such as CDMA or GSM cellular

networks), a wireless network (such as WiFi, WiMAX, LTE, and so forth), or a local area network (or indeed any network topology known in the art; the invention does not prefer any

one network topology over any other). Networks **31** may be implemented using any known network protocols, including for example wired and/or wireless protocols.

[074] In addition, in some embodiments, servers **32** may call external services **37** when

needed to obtain additional information, or to refer to additional data concerning a particular call. Communications with external services **37** may take place, for example, via one or more networks **31**. In various embodiments, external services **37** may comprise web-enabled

services or functionality related to or installed on the hardware device itself. For example, in an embodiment where client applications **24** are implemented on a smartphone or other

electronic device, client applications **24** may obtain information stored in a server system **32** in the cloud or on an external service **37** deployed on one or more of a particular enterprise's or user's premises.

[075] In some embodiments of the invention, clients **33** or servers **32** (or both) may make use of one or more specialized services or appliances that may be deployed locally or

remotely across one or more networks **31**. For example, one or more databases **34** may be used or referred to by one or more embodiments of the invention. It should be understood by one having ordinary skill in the art that databases **34** may be arranged in a wide variety of architectures and using a wide variety of data access and manipulation means. For example,

in various embodiments one or more databases **34** may comprise a relational database system using a structured query language (SQL), while others may comprise an alternative data storage technology such as those referred to in the art as “NoSQL” (for example, HADOOP CASSANDRA™, GOOGLE BIGTABLE™, and so forth). In some embodiments, variant
5 database architectures such as column-oriented databases, in-memory databases, clustered databases, distributed databases, or even flat file data repositories may be used according to the invention. It will be appreciated by one having ordinary skill in the art that any combination of known or future database technologies may be used as appropriate, unless a specific database technology or a specific arrangement of components is specified for a
10 particular embodiment herein. Moreover, it should be appreciated that the term “database” as used herein may refer to a physical database machine, a cluster of machines acting as a single database system, or a logical database within an overall database management system. Unless a specific meaning is specified for a given use of the term “database”, it should be construed to mean any of these senses of the word, all of which are understood as a plain meaning of
15 the term “database” by those having ordinary skill in the art.

[076] Similarly, most embodiments of the invention may make use of one or more security systems **36** and configuration systems **35**. Security and configuration management are common information technology (IT) and web functions, and some amount of each are generally associated with any IT or web systems. It should be understood by one having
20 ordinary skill in the art that any configuration or security subsystems known in the art now or in the future may be used in conjunction with embodiments of the invention without limitation, unless a specific security **36** or configuration system **35** or approach is specifically required by the description of any specific embodiment.

[077] **Fig. 7** shows an exemplary overview of a computer system **40** as may be used in any
25 of the various locations throughout the system. It is exemplary of any computer that may execute code to process data. Various modifications and changes may be made to computer system **40** without departing from the broader scope of the system and method disclosed herein. Central processor unit (CPU) **41** is connected to bus **42**, to which bus is also connected memory **43**, nonvolatile memory **44**, display **47**, input/output (I/O) unit **48**, and
30 network interface card (NIC) **53**. I/O unit **48** may, typically, be connected to keyboard **49**, pointing device **50**, hard disk **52**, and real-time clock **51**. NIC **53** connects to network **54**, which may be the Internet or a local network, which local network may or may not have connections to the Internet. Also shown as part of system **40** is power supply unit **45**

connected, in this example, to a main alternating current (AC) supply **46**. Not shown are batteries that could be present, and many other devices and modifications that are well known but are not applicable to the specific novel functions of the current system and method disclosed herein. It should be appreciated that some or all components illustrated may be combined, such as in various integrated applications, for example Qualcomm or Samsung system-on-a-chip (SOC) devices, or whenever it may be appropriate to combine multiple capabilities or functions into a single hardware device (for instance, in mobile devices such as smartphones, video game consoles, in-vehicle computer systems such as navigation or multimedia systems in automobiles, or other integrated hardware devices).

10 Conceptual Architecture

[078] **Fig. 15** is a block diagram of an exemplary system architecture **1500** for natural body interaction for mixed or virtual reality applications, according to a preferred embodiment of the invention. According to the embodiment, a composition server **1501** comprising programming instructions stored in a memory **11** and operating on a processor **12** of a computing device **10** (as described above, with reference to **Fig. 4**), may be configured to receive a plurality of input data from various connected devices. Such input devices may include (but are not limited to) a variety of hardware controller devices **1504** (such as a gaming controller [such as GOJI PLAY™ controllers], motion tracking controller, or traditional computer input devices such as a keyboard or mouse), a headset device **1503** such as an augmented reality or virtual reality headset (for example, OCULUS RIFT™, HTC VIVE™, SAMSUNG GEAR VR™, MICROSOFT HOLOLENS™, or other headset devices), a variety of fitness devices **1505** (for example, fitness tracking wearable devices such as FITBIT™, MICROSOFT BAND™, APPLE WATCH™, or other wearable devices, or exercise machines such as a treadmill, elliptical trainer, stair-climbing machine, or other such equipment), or a variety of body input **1502** tracking devices or arrangements, such as using a plurality of tethers attached to the environment and a harness worn by a user, configured to track movement and position of the user's body.

[079] Various input devices may be connected to composition server **1501** interchangeably as desired for a particular arrangement or use case, for example a user may wish to use a controller **1504** in each hand and a headset **1503**, but omit the use of fitness devices **1505** altogether. During operation, composition server **1501** may identify connected devices and load any stored configuration corresponding to a particular device or device type, for example

using preconfigured parameters for use as a default configuration for a new controller, or using historical configuration for a headset based on previous configuration or use. For example, a user may be prompted (or may volunteer) to provide configuration data for a particular device, such as by selecting from a list of options (for example, “choose which type
5 of device this is”, or “where are you wearing/holding this device”, or other multiple-choice type selection), or composition server **1501** may employ machine learning to automatically determine or update device configuration as needed. For example, during use, input values may be received that are determined to be “out of bounds”, for example an erroneous sensor reading that might indicate that a user has dramatically shifted position in a way that should
10 be impossible (for example, an erroneous reading that appears to indicate the user has moved across the room and back again within a fraction of a second, or has fallen through the floor, or other data anomalies). These data values may be discarded and configuration updated to reduce the frequency of such errors in the future, increasing the reliability of input data through use.

15 **[080]** Composition server **1501** may receive a wide variety of input data from various connected devices, and by comparing against configuration data may discard undesirable or erroneous readings as well as analyze received input data to determine more complex or fine-grained measurements. For example, combining input from motion-sensing controllers **1504** with a motion-sensing headset **1503** may reveal information about how a user is moving their
20 arms relative to their head or face, such as covering their face to shield against a bright light or an attack (within a game, for example), which might otherwise be impossible to determine with any reliability using only the controllers themselves (as it may be observed that a user is raising their hands easily enough, but there is no reference for the position or movement of their head). These derived input values may then be combined into a single composite input
25 data stream for use by various software applications, such as augmented reality or mixed or virtual reality productivity applications (for example, applications that assist a user in performing manual tasks by presenting virtual information overlays onto their field of vision, or by playing audio directions to instruct them while observing their behavior through input devices, or other such applications), or virtual reality applications or games, such as
30 simulation games that translate a user’s movement or position into in-game interaction, for example by moving a user’s in-game character or avatar based on their physical movements as received from input devices. In some arrangements, composition server **1501** may operate such software applications in a standalone manner, functioning as a computer or gaming

console as needed. In other arrangements, composition server **1501** may provide the composite data for use by an external computer **1510**, such as a connected gaming console, virtual reality device, personal computer, or a server operating via a network in the cloud (such as for online gaming arrangements, for example). In this manner, the composite data
5 functions of the embodiment may be utilized with existing hardware if desired, or may be provided in a standalone package such as for demonstrations or public use, or for convenient setup using a single device to provide the full interaction experience (in a manner similar to a household gaming console, wherein all the functions of computer components may be prepackaged and setup to minimize difficulty for a new user).

10 **[081]** In various embodiments, functionality for implementing systems or methods of the present invention may be distributed among any number of client and/or server components. For example, various software modules may be implemented for performing various functions in connection with the present invention, and such modules may be variously implemented to run on server and/or client components.

15 **[082]** The skilled person will be aware of a range of possible modifications of the various embodiments described above. Accordingly, the present invention is defined by the claims and their equivalents.

What is claimed is:

1. A variable-resistance exercise machine with wireless communication for smart device control and interactive software applications, comprising:

5 a wireless network interface configured to communicate with a plurality of user devices via a network, and configured to receive input from a connected user device and configured to provide output to a connected user device, the input comprising at least a user interaction received via an interactive software application operating on a user device and the output comprising at least a user interaction received via a user device;

10 a plurality of moving surfaces each configured to provide an independent degree of resistance to movement, the degree of resistance being based at least in part on received input from a user device, and configured to detect movement, produce a user interaction based at least in part on detected movement, and provide the user interaction as output to an interactive software application operating on a user device, the output being based at least in part on the detected movement; and

15 a plurality of rigid rails configured to provide a rigid support for a human user to grasp during movement, and configured to provide a plurality of immovable attachment points for a user to affix a variety of external user devices.

20 2. The exercise machine of claim 1, further comprising a plurality of steps configured to assist a human user in mounting and dismounting the exercise machine safely.

25 3. The exercise machine of claim 1, further wherein at least a portion of the plurality of moving surfaces comprises an integrally-formed textured surface configured to provide adequate purchase when pressure is applied by a portion of the user's body.

4. The exercise machine of claim 4, wherein a user device comprises a physical therapist's mobile device.

30 5. The exercise machine of claim 4, wherein a user device comprises a wearable computing device.

6. The exercise machine of claim 1, wherein the interactive software application comprises a virtual reality application.

7. A method for providing rehabilitative care using a variable-resistance exercise machine with wireless communication for smart device control and interactive software applications, comprising the steps of:

5 connecting, using a wireless network interface configured to communicate with a plurality of user devices via a network, and configured to receive input from a connected user device and configured to provide output to a connected user device, to a user device;

 receiving input from the user device;

 varying the resistance of at least a portion of a plurality of moving surfaces each
10 configured to provide an independent degree of resistance to movement, the degree of resistance being based at least in part on received input from a user device, and configured to detect movement and provide output to a user device, the output being based at least in part on the detected movement, the resistance being based at least in part on the input from the user device;

15 detecting movement comprising at least a user's ability to counter the resistance of at least a portion of the moving surfaces; and

 providing output to the user device based at least in part on the detected movement.

8. A system for natural body interaction for mixed or virtual reality applications, comprising:

20 a composition server comprising at least a plurality of programming instructions stored in a memory and operating on a processor of a network-connected computing device and configured to receive input data from a plurality of hardware devices via a network, and configured to operate a virtual control stick, and configured to produce a plurality of operations of the virtual control stick based at least in part on at least a portion of the received
25 input data, and configured to produce a composite data stream based at least in part on at least a portion of the received input data and the virtual control stick operations.

9. The system of claim 8, further wherein the input data comprises at least a plurality of motion tracking data.

30

10. The system of claim 9, wherein the motion tracking data corresponds to movement of at least a human user's torso.

11. The system of claim 10, wherein the operations of the virtual control stick are based at least in part on the movement of the human user's torso.

12. A method for natural body interaction for mixed or virtual reality applications,

5 comprising the steps of:

receiving, at a composition server comprising at least a plurality of programming instructions stored in a memory and operating on a processor of a network-connected computing device and configured to receive input data from a plurality of hardware devices via a network, and configured to operate a virtual control stick, and configured to produce a plurality of operations of the virtual control stick based at least in part on at least a portion of the received input data, and configured to produce a composite data stream based at least in part on at least a portion of the received input data and the virtual control stick operations, a plurality of device inputs;

creating a virtual control stick software device; and

15 directing the operation of the virtual control stick based at least in part on at least a portion of the device inputs.

13. The method of claim 12, further comprising the step of comparing at least a portion of the device inputs against known configuration data.

20

14. The method of claim 13, further comprising the step of producing a composite data stream based at least in part on the comparison results.

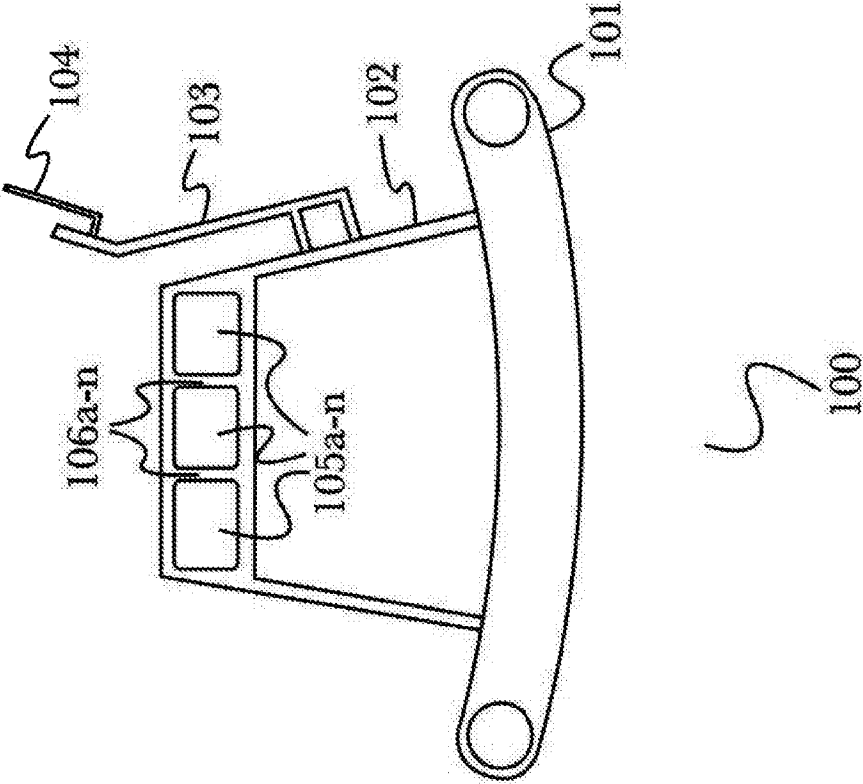


Fig. 1

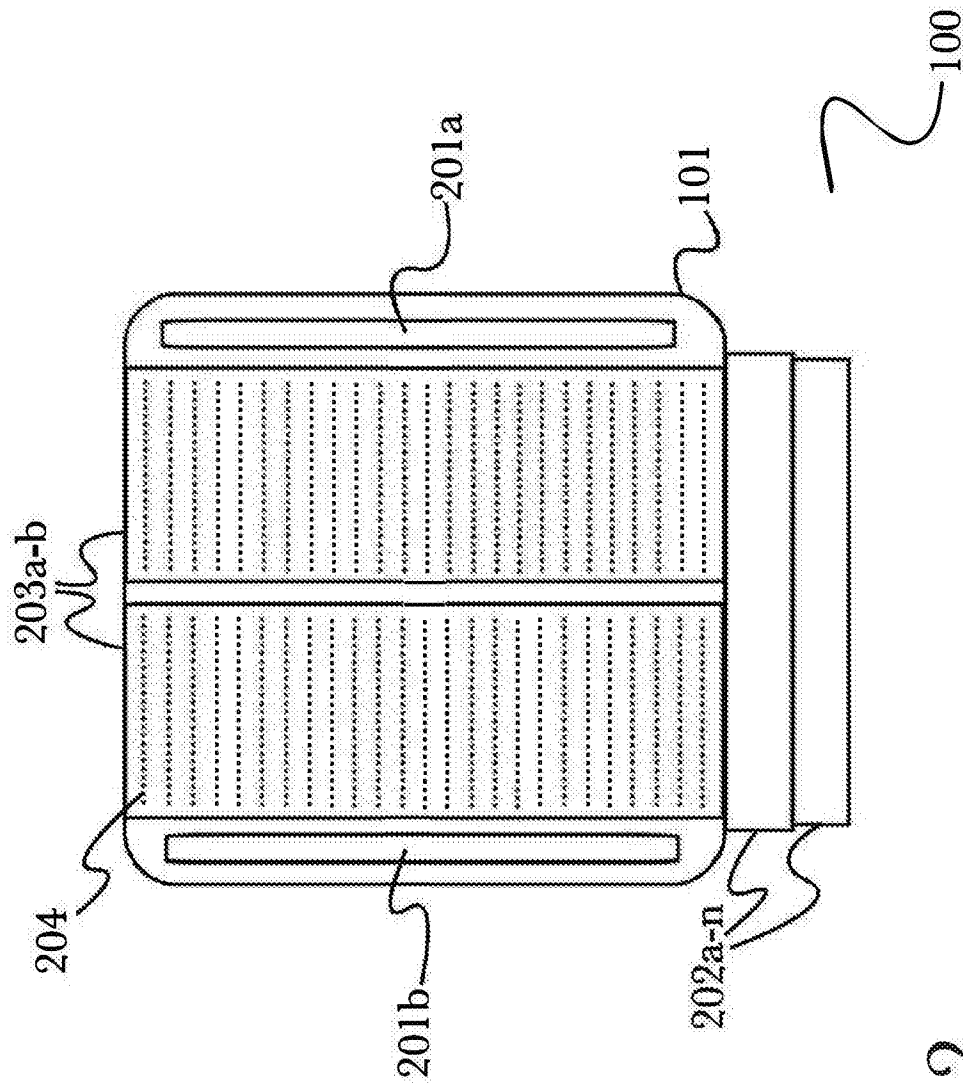


Fig. 2

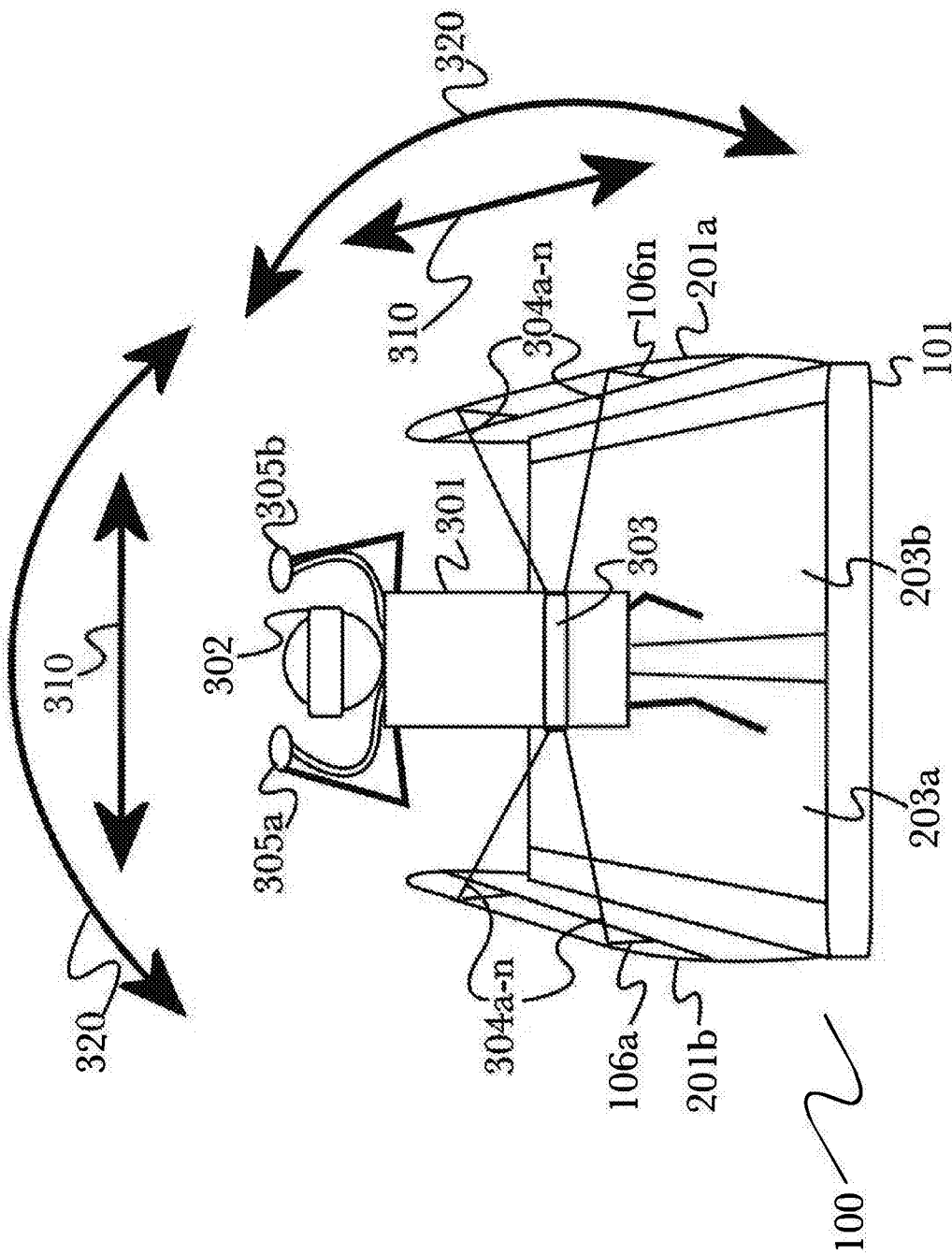


Fig. 3

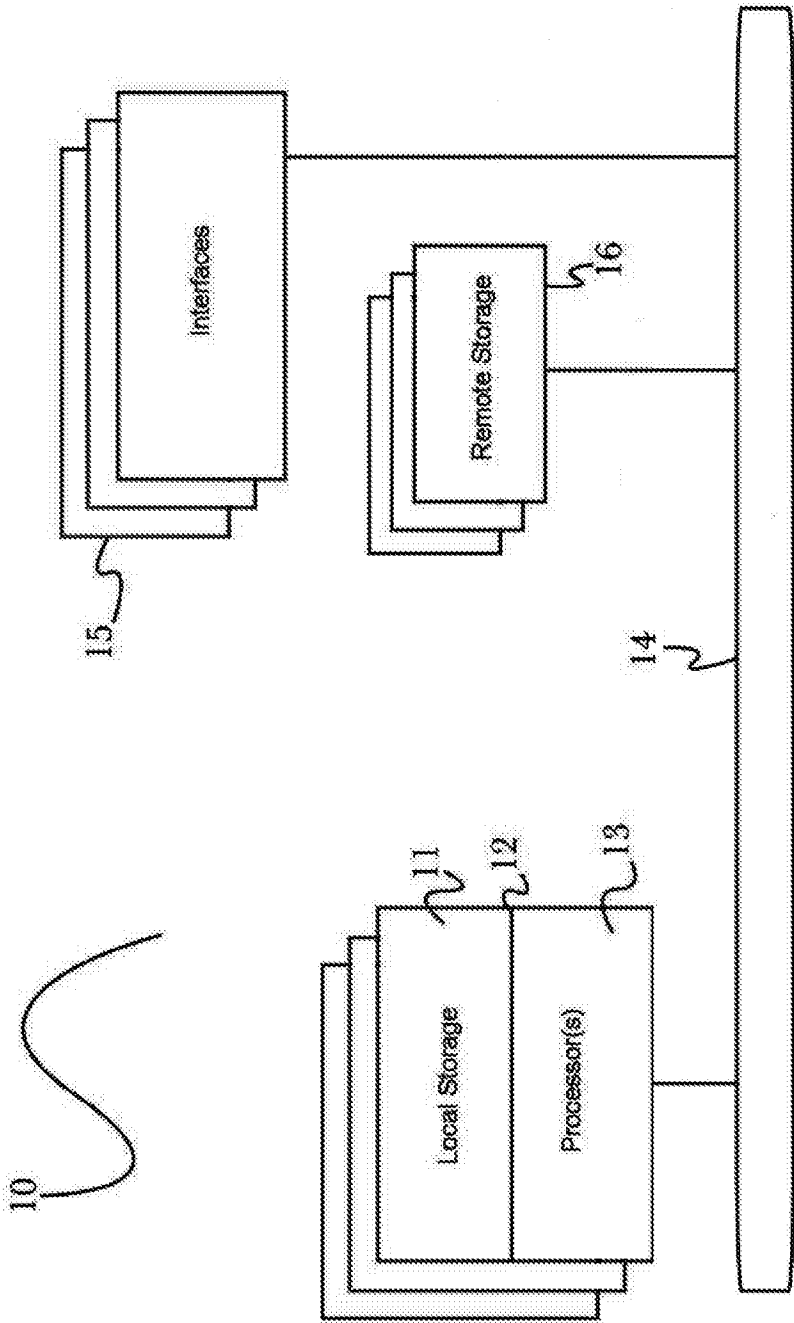


Fig. 4

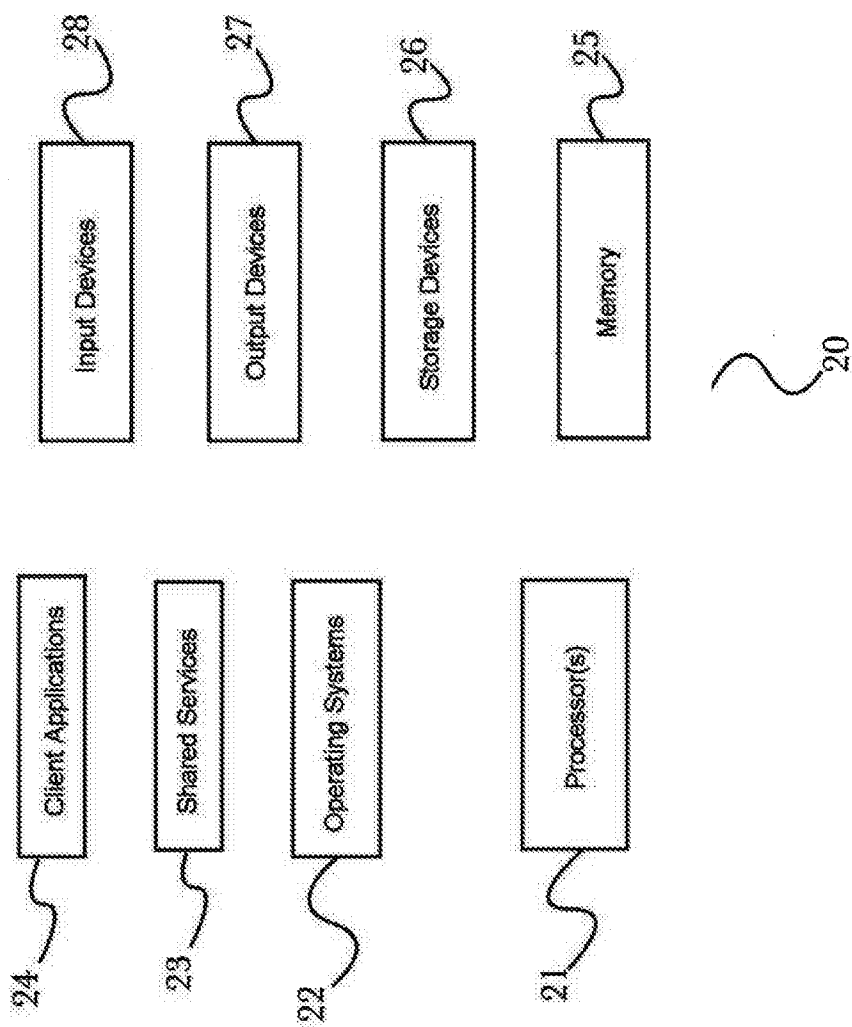


Fig. 5

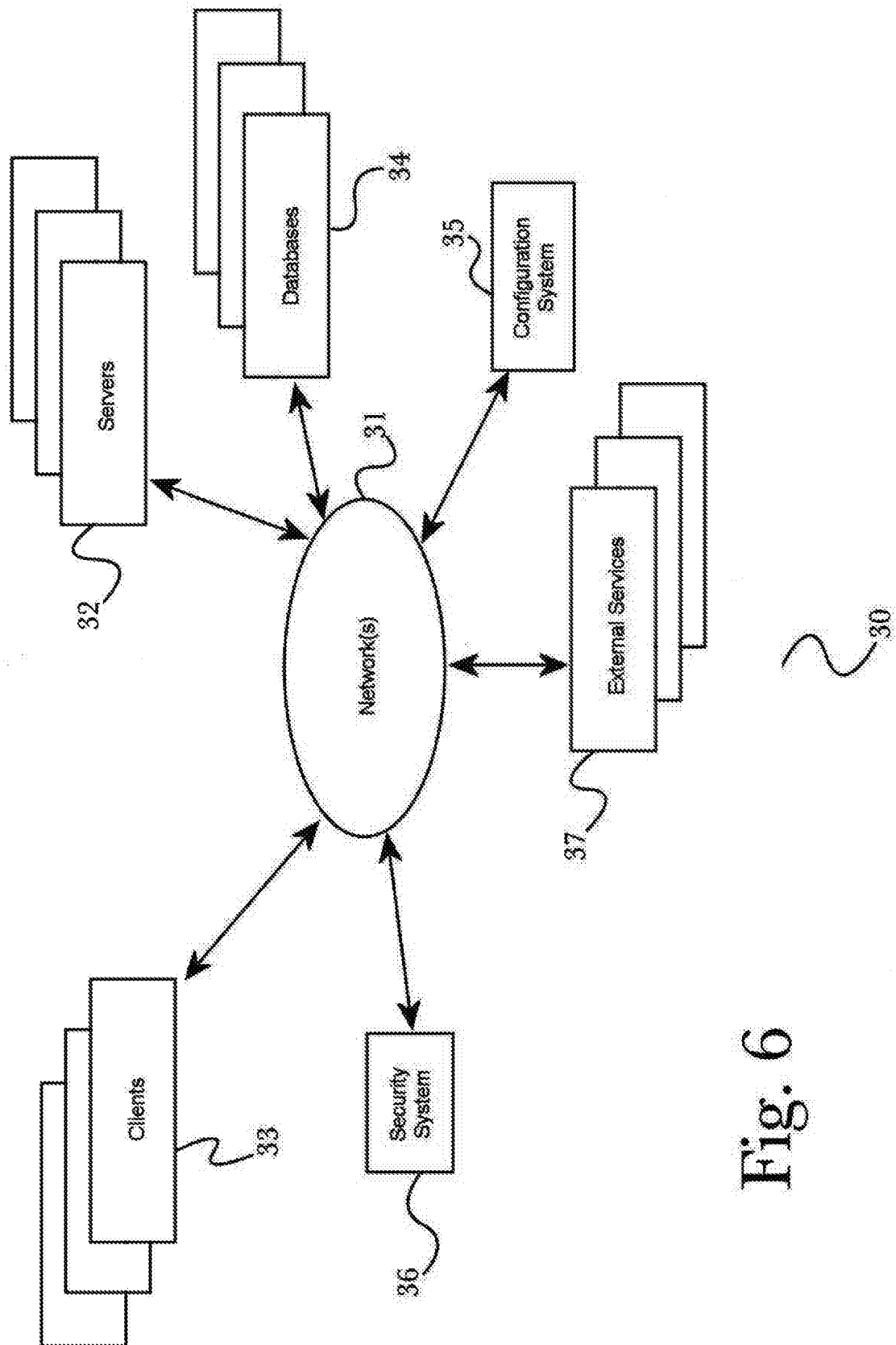


Fig. 6

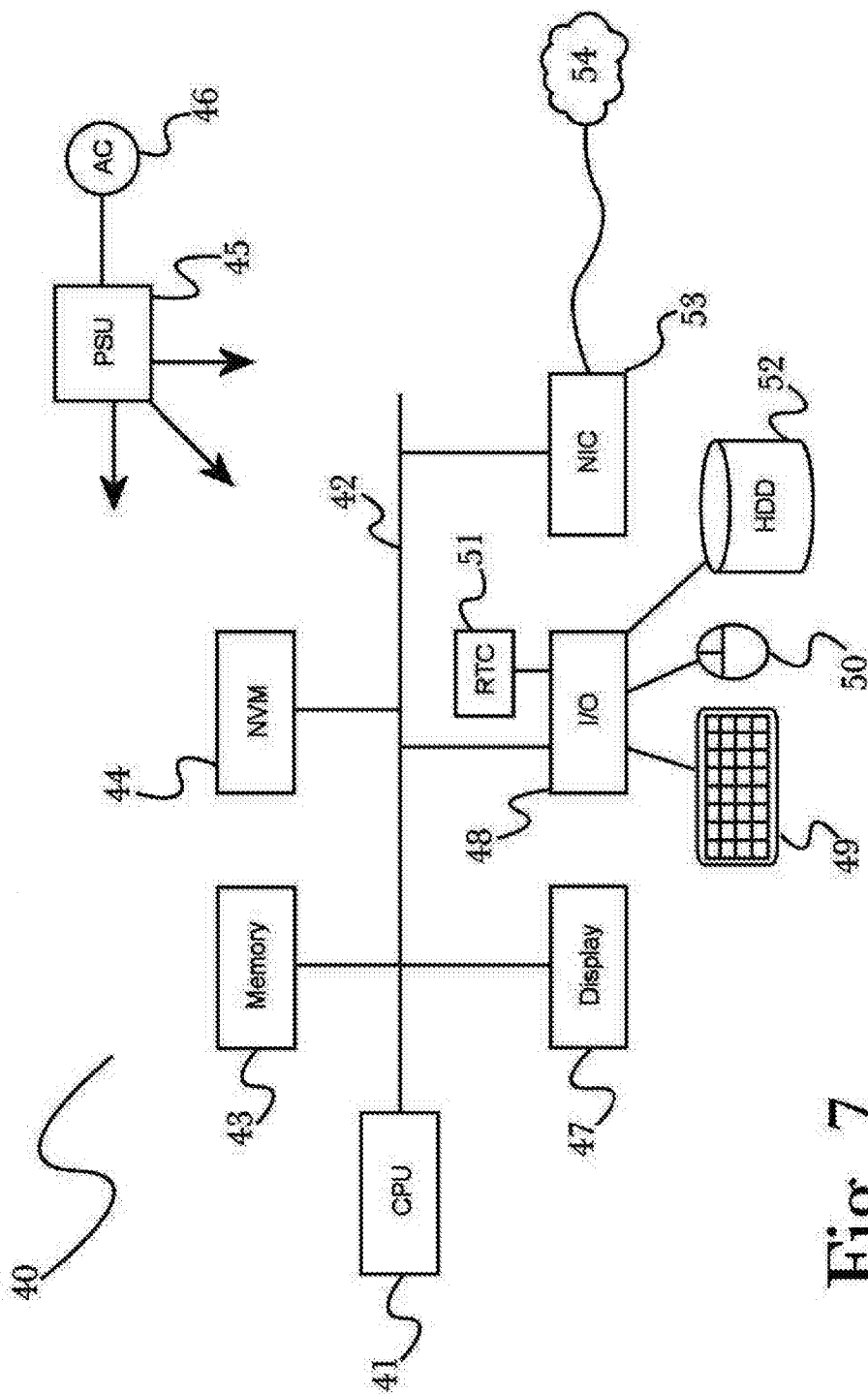


Fig. 7

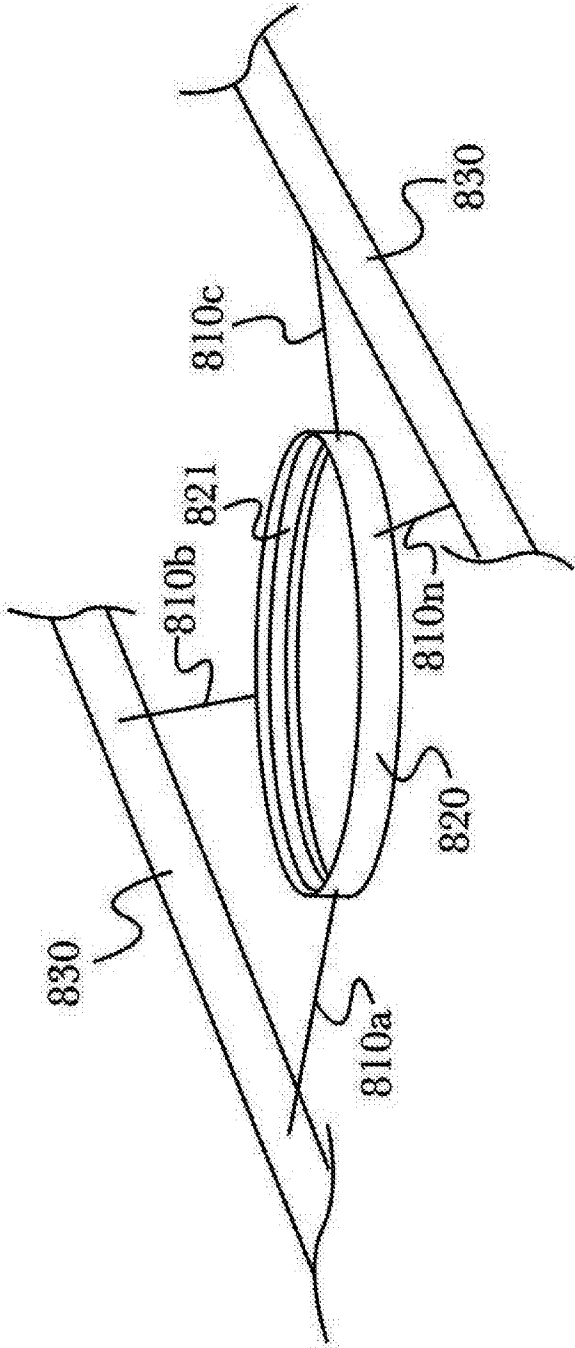


Fig. 8

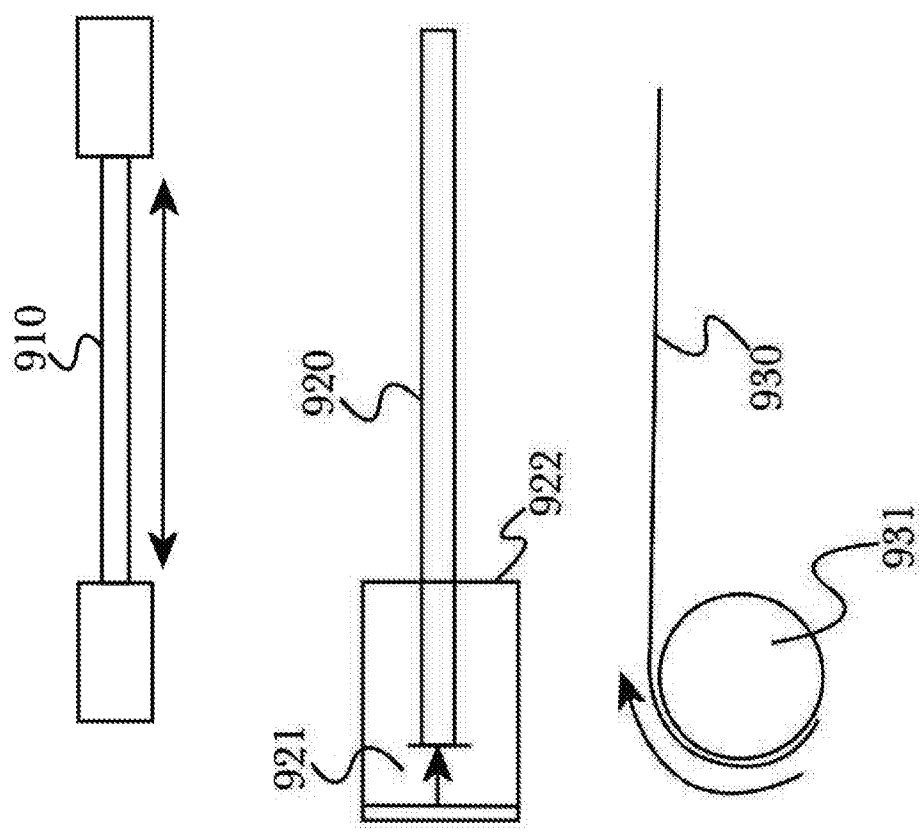


Fig. 9

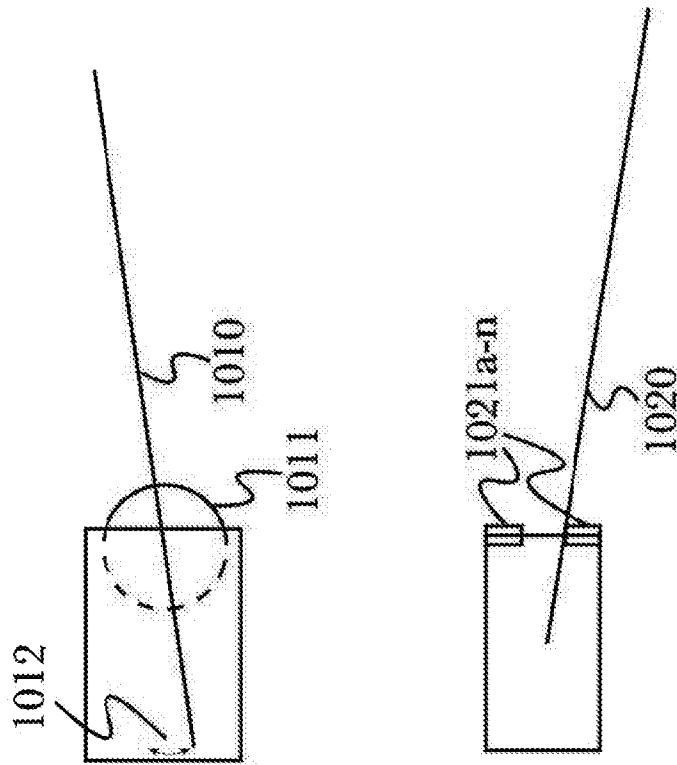


Fig. 10

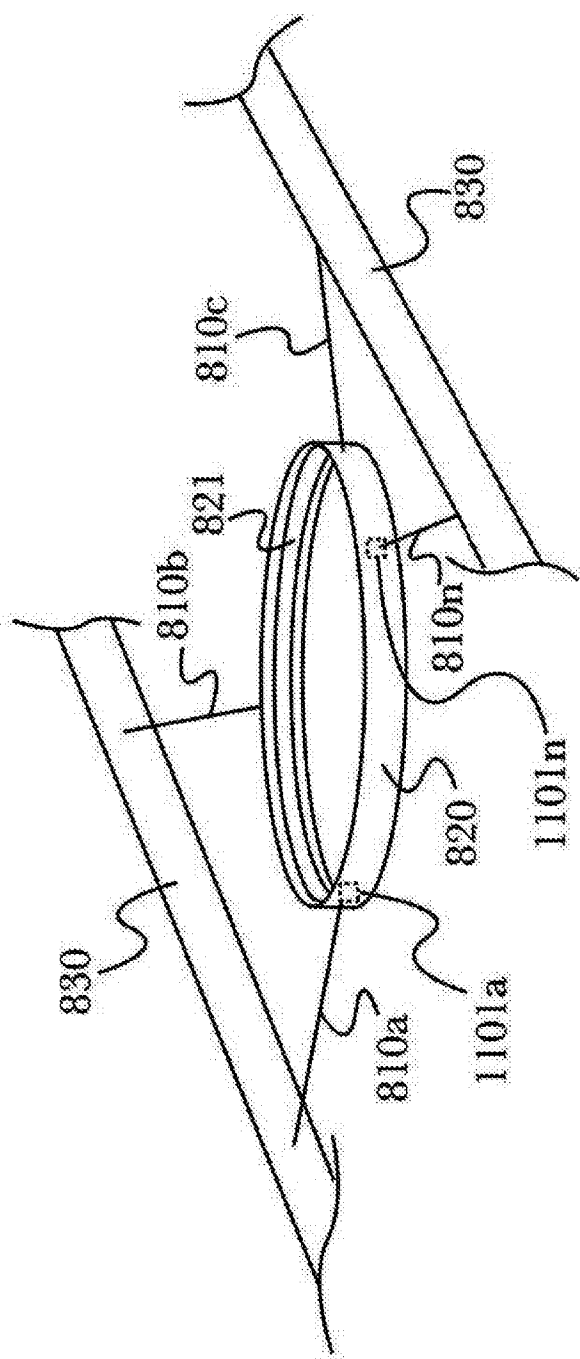


Fig. 11

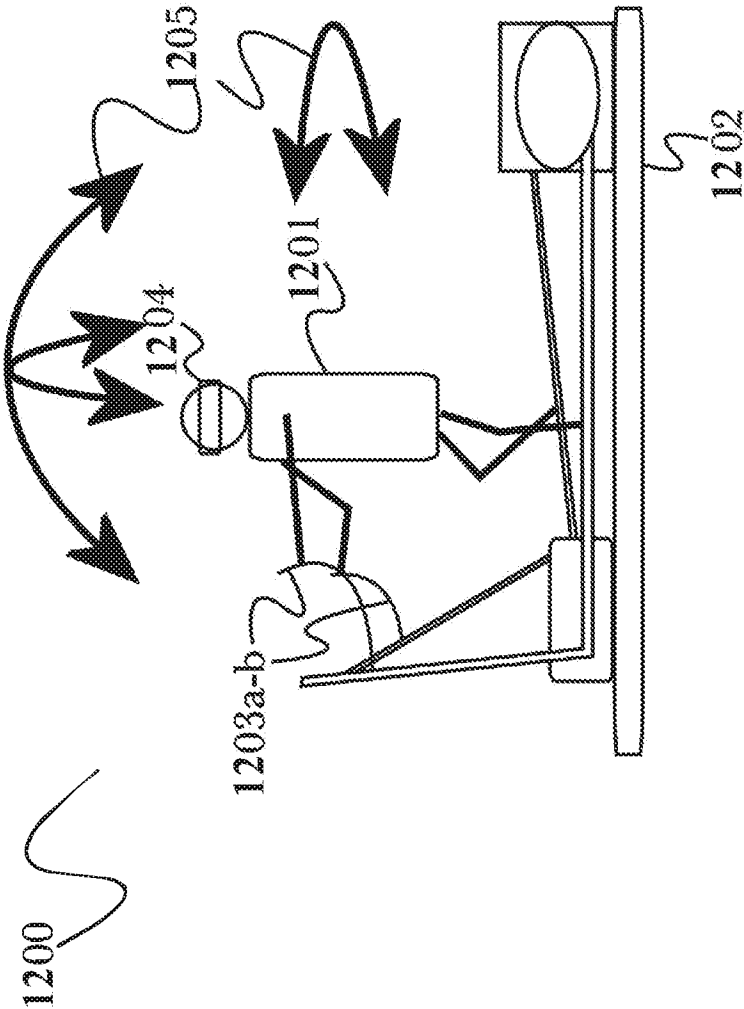


Fig. 12

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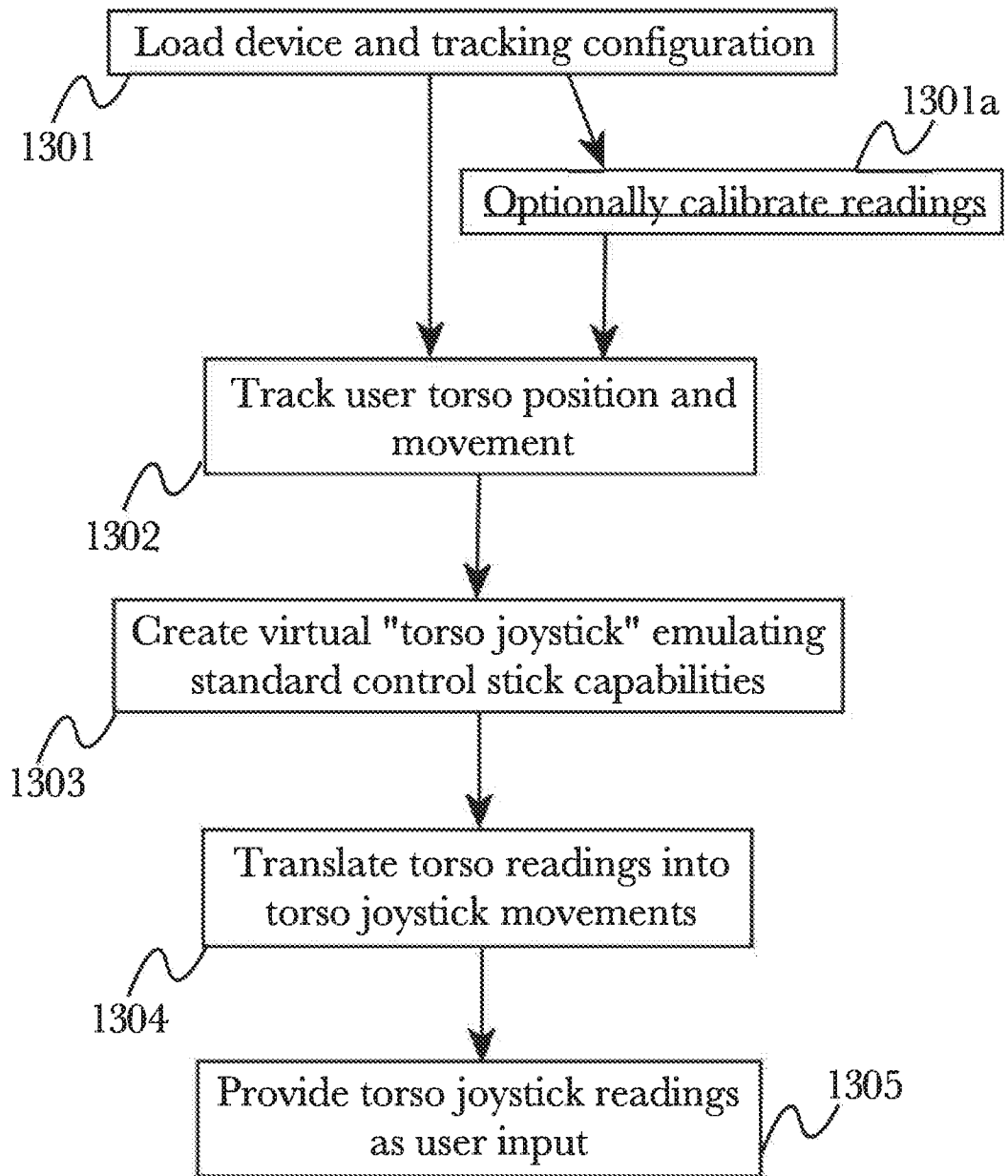


Fig. 13

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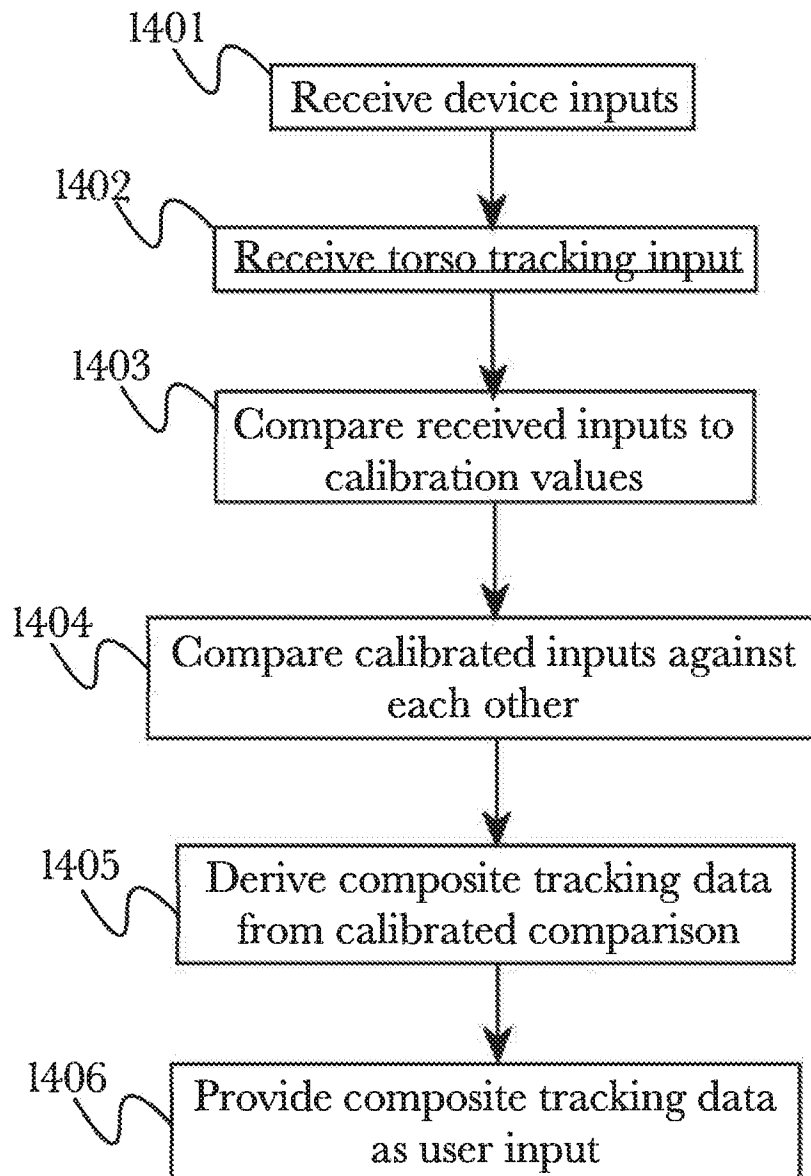


Fig. 14

1400

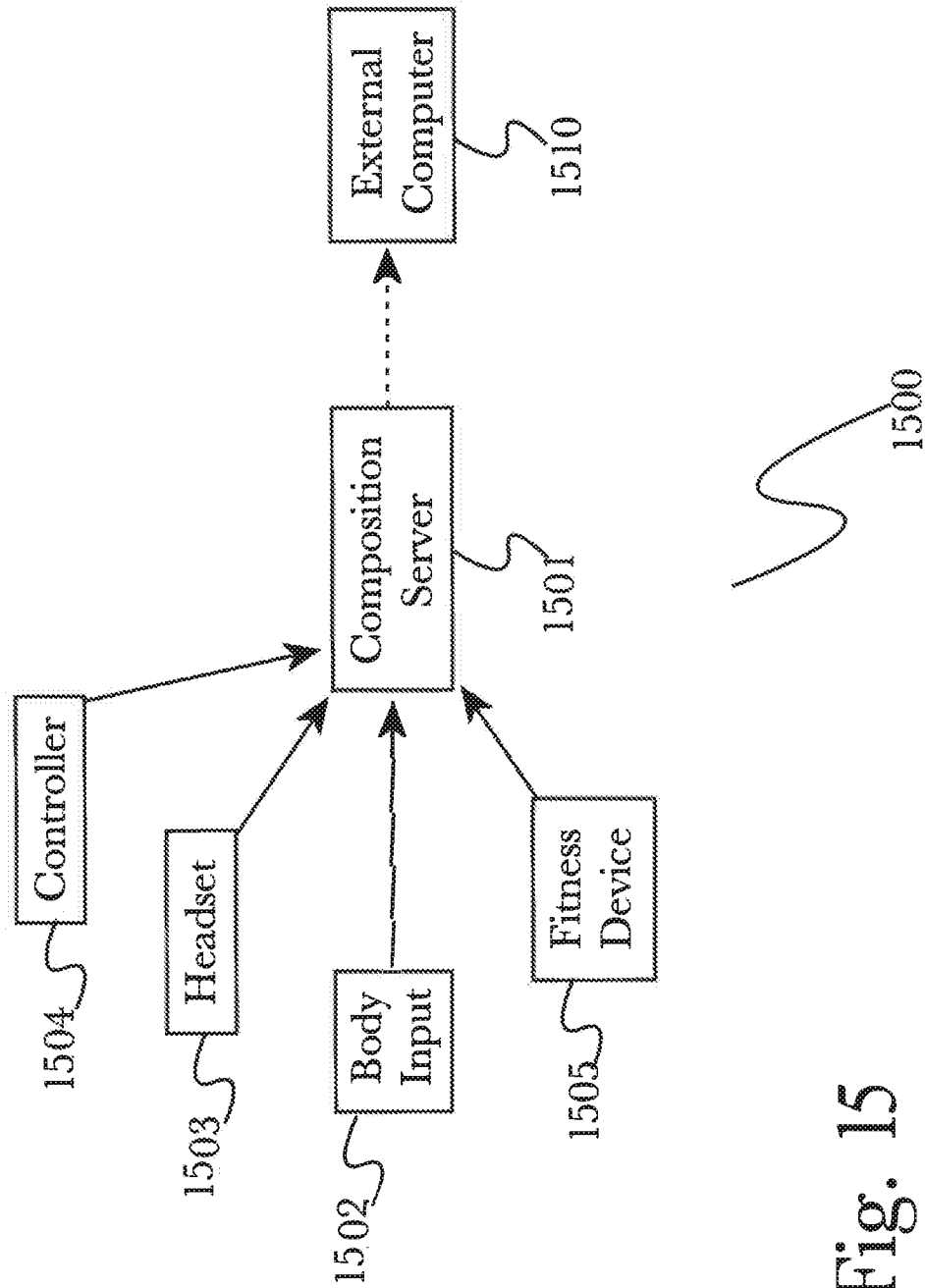


Fig. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/030697

A. CLASSIFICATION OF SUBJECT MATTER												
<i>A63B 21/00 (2006.01)</i> <i>A63B 24/00 (2006.01)</i>												
According to International Patent Classification (IPC) or to both national classification and IPC												
B. FIELDS SEARCHED												
Minimum documentation searched (classification system followed by classification symbols)												
A63B 24/00, 22/00, 21/00												
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched												
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)												
PatSearch (RUPTO internal), Esp@cenet, PAJ, USPTO, Information Retrieval System of FIPS												
C. DOCUMENTS CONSIDERED TO BE RELEVANT												
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.										
Y	US 7815549 B2 (NAUTILUS, INC.) 19.10.2010, p. 2, col. 3, lines 3-23, claims 10, 14, 15, fig. 1-8, 50-57	1-7										
X	US 2014/0066201 A1 (BLUE GOJI CORP.) 06.03.2014, paragraphs [0021] - [0033], [0047] - [0050], [0056] - [0066], [0070] - [0073], fig. 1-7	8-14										
Y		1-7										
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.												
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“A” document defining the general state of the art which is not considered to be of particular relevance	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention											
“E” earlier document but published on or after the international filing date	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone											
“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art											
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“P” document published prior to the international filing date but later than the priority date claimed												
Date of the actual completion of the international search		Date of mailing of the international search report										
25 September 2017 (25.09.2017)		12 October 2017 (12.10.2017)										
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37		Authorized officer A. Artemiev Telephone No. (495)531-64-81										