334, such as RAM and/or ROM, is preferably coupled to microprocessor **330** to store instructions for microprocessor **330** and store temporary and other data.

Sensor interface **336** may optionally be included in device **320** to convert sensor signals to signals that can be interpreted by the microprocessor **330** and/or host computer system **16**. For example, sensor interface **336** can receive and convert signals from a digital sensor such as an encoder or from an analog sensor using an analog to digital converter (ADC). Such circuits, or equivalent circuits, are well known to those skilled in the art. Alternately, microprocessor **330** or host computer **16** can perform these interface functions. Actuator interface **338** can be optionally connected between the actuators of device **320** and microprocessor **330** to convert signals from microprocessor **330** into signals appropriate to drive the actuators. Interface **338** can include power amplifiers, switches, digital to analog controllers (DACs), and other components well known to those skilled in the art. Power supply **340** can optionally be coupled to actuator interface **338** and/or actuators **342** to provide electrical power. Alternatively, if the USB or a similar communication protocol is used, actuators and other components can draw power from the USB from the host computer. Or, power can be stored and regulated by device **320** and used when needed to drive actuators **342**.

Sensors **344** sense the position, motion, and/or other characteristics of particular controls of device **320**; for example, sensors **344** can be sensor **126** or the sensors of linkage **20** as described above. Sensors **344** provide signals to microprocessor **330** including information representative of those characteristics. The sensor **344** or sensor interface **336** can optionally provide sensor signals directly to computer **16** as shown by busses **21**_a_ and **21**_b_. Typically, a sensor **344** is provided for each degree of freedom in which a manipulandum can be moved and is desired to be sensed, or, a single compound sensor can be used for multiple degrees of freedom. Example of sensors suitable for embodiments described herein are Hall effect sensors, digital rotary optical encoders, linear optical encoders, analog sensors such as potentiometers, optical sensors such as a lateral effect photo diode, velocity sensors (e.g., tachometers) and/or acceleration sensors (e.g., accelerometers). Furthermore, either relative or absolute sensors can be employed.

Actuators **342** transmit forces to particular controls of device **320** in one or more directions along one or more degrees of freedom in response to signals output by microprocessor **330** and/or host computer **16**, i.e., they are "computer controlled." Actuators **342** can include two types: active actuators and passive actuators. Actuators **342** are preferably the voice coil actuators **150** described above, but can be implemented as other types in different embodiments, such as linear current control motors, stepper motors, pneumatic/hydraulic active actuators, a torquer (motor with limited angular range), magnetic particle brakes, friction brakes, or pneumatic/hydraulic passive actuators. For example, actuators **342** can include actuator **102**, **124**, **186**, **226**, or **300**.

The control **350** can be a variety of different objects or manipulandums that are manipulated by a user and which can receive haptic feedback. For example, control **350** can be the finger pads **78** which are sensed and actuated; and/or control **350** can be the entire controller **22** whose housing is actuated (or just the moveable portion that is actuated) and whose position is sensed through linkage **20**, for example. Other controls can also be provided as described above. Different types of mechanisms can be used to output force onto controls (such as finger pads **78**) and provide the controls with degrees of freedom. Different mechanisms and related features are disclosed in U.S. Pat. Nos. 5,576,727; 5,721,566; 5,691,898; 5,767,839; 5,805,140 and co-pending patent applications Ser. Nos. 08/709,012, 08/736,161, 08/961,790, 08/965,720, and 09/058,259, all hereby incorporated by reference herein their entirety.

Other input devices **346** can optionally be included in device **320** and send input signals to microprocessor **330** and/or host computer **16**. Such input devices can include buttons, dials, knobs, switches, voice recognition hardware (with software implemented by host **18**), or other input mechanisms as described above. Safety or "deadman" switch **348** can be included in some embodiments of device **320** to provide a mechanism to allow a user to override and deactivate forces output by actuators **342**, or require a user to activate actuators **342**, for safety reasons. For example, the user can be required to continually activate or close safety switch **348** during manipulation of the device **320** to activate the actuators **342**. Embodiments of safety switch **348** include an optical safety switch, electrostatic contact switch, hand weight safety switch, etc.

While this invention has been described in terms of several preferred embodiments, it is contemplated that alterations, permutations, and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. For example, the embodiments of the control devices described herein can be used in a variety of applications, from telemanipulator systems to haptic feedback interfacing with computer simulations. In addition, the features described herein can be used interchangeably with other embodiments. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention. It is therefore intended that the following appended claims include all such alterations, permutations and equivalents as fall within the true spirit and scope of the present invention.

What is claimed is:

1. A device, comprising:

a housing having a fixed portion and a first moveable portion defined as a first partial outer surface of the housing and a second moveable portion defined as a partial second outer surface of the housing located opposite to the first partial outer surface, the housing to be grasped by a user and the fixed portion moveable in three dimensions with respect to ground during operation, the first and second moveable portions including pads configured to be selectively moved toward and away each other;

a sensor coupled to the housing and configured to measure positional values of the fixed portion when moved in the three dimensions;

a flexure member coupled to at least the first moveable portion and the fixed portion, wherein the flexure member is configured to allow selective movement of the first moveable portion with respect to the fixed portion; and

an actuator coupled to the flexure member, the actuator configured to output haptic feedback to the first and second moveable portions of the housing via the flexure member.

2. The device of claim **1**, wherein the haptic feedback is output based on an oscillation of a shaft of the actuator.

3. The device of claim **1**, wherein the flexure member includes a first flexure member and a second flexure member, the first flexure member and the second flexure member being coupled between the first moveable portion and the fixed portion, the actuator being configured to output the haptic feedback via at least one of the flexure members.