[0018] **FIGS. 7A** though **7D** are schematic side views of embodiments of palm forcing mechanisms including cams according to the invention;

[0019] **FIG. 8** is a schematic sectional side view of an embodiment of a palm forcing mechanism including an inflatable air bladder;

[0020] **FIG. 9** is a schematic sectional side view of an embodiment of a palm forcing mechanism with multiple contacting points;

[0021] **FIG. 10** is a schematic sectional side view of an embodiment of a forcing mechanism according to the invention applying a force to a portion of the body other than the palm;

[0022] **FIG. 11** is a schematic side view of a haptic interface device comprising a palm forcing mechanism and a finger forcing mechanism;

[0023] **FIG. 12** is a schematic perspective view of a finger sensing mouse; **FIG. 13** is a schematic sectional side view of a version of a tactile finger sensing mouse;

[0024] **FIG. 14** is a schematic sectional side view of another version of a tactile finger sensing mouse;

[0025] **FIG. 15** is a schematic block diagram of a simulation system comprising a tactile mouse;

[0026] **FIG. 16** is a schematic perspective view of a version of a force feedback finger sensing mouse;

[0027] **FIGS. 17A through 17C** are schematic perspective views of the forcing mechanism of the version of a force feedback finger sensing mouse of **FIG. 16**;

[0028] **FIG. 18** is a schematic block diagram of a simulation system comprising a force feedback finger sensing mouse;

[0029] **FIGS. 19A through 19C** are schematic sectional side views of finger sensing mechanisms usable with a mouse device;

[0030] **FIG. 20A** is a schematic sectional side view of a finger sensing mechanism comprising a finger receiving extension;

[0031] **FIG. 20B** is a schematic view along B-B of the finger receiving extension of **FIG. 20A**;

[0032] **FIG. 21** is a schematic sectional side view of another version of a finger sensing mechanism usable with a mouse device;

[0033] **FIG. 22** is a schematic sectional side view of another version of a finger sensing mechanism usable with a mouse device;

[0034] **FIGS. 23A and 23B** are schematic side views of a finger sensing button comprising multiple portions;

[0035] **FIG. 24** is a schematic perspective view of a three dimensional finger sensing mouse; and

[0036] **FIGS. 25A through 25C** are schematic views of alternative designs for a mouse device.

## DESCRIPTION

[0037] The present invention relates to virtual reality simulations and more particularly to computer simulations involving the control of a graphical image, such as a graphical image that is a graphical representation of a hand or a portion of a hand. Although the process is illustrated at least partly in the context of controlling a graphical hand, the present invention can be used in other simulation and computer interactive processes and/or to control other graphical images and should not be limited to the examples provided herein.

[0038] **FIG. 1** is a schematic illustration of a simulation system **100** according to the invention. The simulation system **100** is capable of generting a virtual reality environment. A display **105** provides a graphical environment **110** to a user. Within the graphical environment **110** is a graphical image **115**. The graphical image **115** may be, for example, a cursor or other graphical object, the position, movement, and/or shape of which is controllable. For example, the graphical image **115** may be a pointer cursor, a character in a game, a surgical instrument, a view from the end of a surgical instrument, a representative portion of the user, or the like. Also within the graphical environment is a graphical object **120** such as a ball, as shown, or any other graphical representation including another graphical image that may be controlled by the user or by another user. A controller **125** in communication with the display **105** is capable of generating and/or controlling the graphical environment **110**, for example by executing program code including an application program related to the simulation. A user object **130** is manipulatable by a user, and the manipulation of the user object **130** controls the position, orientation, shape and/or other characteristic of the graphical image **115** within the graphical environment **110**, for example by directly correlating a position of the user object **130** with a displayed position of the graphical image **115** or by correlating a position of the user object **130** with a rate of movement of the graphical image **115**. Either the entire user object **130** may be manipulatable by the user or a portion of the user object **130** may be manipulatable relative to another portion of the user object **130**. For example, the user object may be a surface that is engaged by one or more hands of a user, such as a joystick, a mouse, a mouse housing, a stylus, a knob, an elongated rigid or flexible member, an instrumented glove, or the like and may be moveable in from one to six degrees of freedom.

[0039] Optionally, haptic feedback may be provided to the user to increase the realism of the virtual reality environment. For example, when a predetermined event occurs within the graphical environment **110**, such as an interaction of the graphical image **115** with the graphical object **120**, the controller **125** may cause an actuator **135** to output a haptic sensation to the user. In the version shown, the actuator **135** outputs the haptic sensation to the user object **130** through which the sensation is provided to the user. The actuator **135** and the user object **130** may be part of a haptic interface device **140**. The actuator **135** may be positioned in the haptic interface device **140** to apply a force to the user object **130** or to a portion of the user object. For example, the haptic interface device **140** may comprise a user object **130**, such as a mouse housing, having an actuator **135** within the user object **130**, such as a vibrating motor within the mouse housing, or the haptic interface device may comprise a user object **130**, such as a mouse, that is mechanically linked to an actuator **135**. Alternatively, the actuator **135** and the user object **130** may be separate structures, and the actuator **135**