

[0018] FIGS. 7A through 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;

[0024] FIG. 13 is a schematic sectional side view of a version of a tactile finger sensing mouse;

[0025] FIG. 14 is a schematic sectional side view, of another version of a tactile finger sensing mouse;

[0026] FIG. 15 is a schematic block diagram of a simulation system comprising a tactile mouse;

[0027] FIG. 16 is a schematic perspective view of a version of a force feedback finger sensing mouse;

[0028] 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;

[0029] FIG. 18 is a schematic block diagram of a simulation system comprising a force feedback finger sensing mouse;

[0030] FIGS. 19A through 19C are schematic sectional side views of finger sensing mechanisms usable with a mouse device;

[0031] FIG. 20A is a schematic sectional side view of a finger sensing mechanism comprising a finger receiving extension;

[0032] FIG. 20B is a schematic view along B-B of the finger receiving extension of FIG. 20A;

[0033] FIG. 21 is a schematic sectional side view of another version of a finger sensing mechanism usable with a mouse device;

[0034] FIG. 22 is a schematic sectional side view of another version of a finger sensing mechanism usable with a mouse device

[0035] FIG. 23A and 23B are schematic side views of a finger sensing button comprising multiple portions;

[0036] FIG. 24 is a schematic perspective view of a three dimensional finger sensing mouse; and

[0037] FIGS. 25A through 25C are schematic views of alternative designs for a mouse device.

DESCRIPTION

[0038] 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.

[0039] FIG. 1 is a schematic illustration of a simulation system 100 according to the invention. The simulation system 100 is capable of generating 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.

[0040] 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