

[0039] Other devices may also be incorporated or coupled to the computer **10**, such as storage devices (hard disk drive, DVD-ROM drive, etc.), network server or clients, game controllers, etc. In alternate embodiments, the computer **10** can take a wide variety of forms, including computing devices that rest on a tabletop or other surface, stand-up arcade game machines, other portable devices or devices worn on the person, handheld or used with a single hand of the user, etc. For example, host computer **10** can be a video game console, personal computer, workstation, a television “set top box” or a “network computer”, or other computing or electronic device.

[0040] Touchpad device **16** of the present invention preferably appears externally to be similar to the touchpads of the prior art. In many embodiments disclosed herein, such a pad **16** includes a planar, rectangular smooth surface that can be positioned below the keyboard **14** on the housing of the computer **10**, as shown, or may be positioned at other areas of the housing. When the user operates the computer **10**, the user may conveniently place a fingertip or other object on the touchpad **16** and move the fingertip to correspondingly move cursor **20** in the graphical environment **18**.

[0041] In operation, the touchpad **16** inputs coordinate data to the main microprocessor(s) of the computer **10** based on the sensed location of an object on (or near) the touchpad. As with many touchpads of the prior art, touchpad **16** can be capacitive, resistive, or use a different type of sensing. Some existing touchpad embodiments are disclosed, for example, in U.S. Pat. Nos. 5,521,336 and 5,943,044. Capacitive touchpads typically sense the location of an object on or near the surface of the touchpad based on capacitive coupling between capacitors in the touchpad and the object. Resistive touchpads are typically pressure-sensitive, detecting the pressure of a finger, stylus, or other object against the pad, where the pressure causes conductive layers, traces, switches, etc. in the pad to electrically connect. Some resistive or other types of touchpads can detect the amount of pressure applied by the user and can use the degree of pressure for proportional or variable input to the computer **10**. Resistive touchpads typically are at least partially deformable, so that when a pressure is applied to a particular location, the conductors at that location are brought into electrical contact. Such deformability can be useful in the present invention since it can potentially amplify the magnitude of output forces such as pulses or vibrations on the touchpad as used in the present invention. Forces can be amplified if a tuned compliant suspension is provided between an actuator and the object that is moved, as described in provisional application No. 60/157,206, incorporated herein by reference. Capacitive touchpads and other types of touchpads that do not require significant contact pressure may be better suited for the present invention in some embodiments, since excessive pressure on the touchpad may in some cases interfere with the motion of the touchpad for haptic feedback. Other types of sensing technologies can also be used in the touchpad. Herein, the term “touchpad” preferably includes the surface of the touchpad **16** as well as any sensing apparatus included in the touchpad unit.

[0042] Touchpad **16** can operate similarly to existing touchpads, where the speed of the fingertip on the touchpad correlates to the distance that the cursor is moved in the graphical environment. For example, if the user moves his or

her finger quickly across the pad, the cursor is moved a greater distance than if the user moves the fingertip more slowly. If the user’s finger reaches the edge of the touchpad before the cursor reaches a desired destination in that direction, then the user can simply move his or her finger off the touchpad, reposition the finger away from the edge, and continue moving the cursor. This is an “indexing” function similar to lifting a mouse off a surface to change the offset between mouse position and cursor. Furthermore, many touchpads can be provided with particular regions that are each assigned to particular functions that can be unrelated to cursor positioning. Such an embodiment is described in greater detail below with respect to **FIG. 18**. In some embodiments the touchpad **16** may also allow a user to “tap” the touchpad (rapidly touch and remove the object from the pad) in a particular location to provide a command. For example, the user can tap or “double tap” the pad with a finger while the controlled cursor is over an icon to select that icon.

[0043] In the present invention, the touchpad **16** is provided with the ability to output haptic feedback such as tactile sensations to the user who is physically contacting the touchpad **16**. Various embodiments detailing the structure of the haptic feedback touchpad are described in greater detail below. Some embodiments may move a device housing or separate moving surface, not the touchpad itself.

[0044] Using one or more actuators coupled to the touchpad **16** or an associated surface, a variety of haptic sensations can be output to the user who is contacting the touchpad (or housing or separate surface). For example, jolts, vibrations (varying or constant amplitude), and textures can be output. Forces output to the user can be at least in part based on the location of the finger on the pad or the state of a controlled object in the graphical environment of the host computer **10**, and/or independent of finger position or object state. Such forces output to the user are considered “computer-controlled” since a microprocessor or other electronic controller is controlling the magnitude and/or direction of the force output of the actuator(s) using electronic signals.

[0045] In other embodiments, the touchpad **16** can be provided in a separate housing that is connected to a port of the computer **10** via a cable or via wireless transmission and which receives force information from and sends position information to the computer **10**. For example, Universal Serial Bus (USB), Firewire, or a standard serial bus can connect such a touchpad to the computer **10**.

[0046] One or more buttons **26** can also be provided on the housing of the computer **10** to be used in conjunction with the touchpad **16**. The user’s hands have easy access to the buttons, each of which may be pressed by the user to provide a distinct input signal to the host computer **12**. Typically, each button **26** corresponds to a similar button found on a mouse input device, so that a left button can be used to select a graphical object (click or double click), a right button can bring up a context menu, etc. In some embodiments, one or more of the buttons **26** can be provided with tactile feedback as described in U.S. Pat. No. 6,184,868 and application Ser. No. 09/467,309, and both incorporated herein by reference in their entirety. Other features of these disclosures may also be used with the present invention.

[0047] Furthermore, in some embodiments, one or more moveable portions **28** of the housing of the computer device