

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a haptic touchpad of the present invention;

FIG. 2 is a perspective view of a remote control device including the touchpad of the present invention;

FIG. 3 is a perspective view of a first embodiment of the touchpad of the present invention including one or more actuators coupled to the underside of the touchpad;

FIG. 4 is a side elevational view of a first embodiment of the present invention in which a piezo-electric actuator is directly coupled to the touchpad of the present invention;

FIG. 5 is a side elevational view of a second embodiment of the touchpad of the present invention including a linear actuator;

FIG. 6 is a side elevational view of a third embodiment of the touchpad of the present invention having an inertial mass;

FIG. 7 is a top plan view of an example of a touchpad of the present invention having different control regions; and

FIGS. 8a and 8b are top plan and side cross sectional views, respectively, of a touch screen embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a perspective view of a portable computer 10 including a haptic touchpad of the present invention. Computer 10 is preferably a portable or "laptop" computer that can be carried or otherwise transported by the user and may be powered by batteries or other portable energy source in addition to other more stationary power sources. Computer 10 preferably runs one or more host application programs with which a user is interacting via peripherals.

Computer 10 may include the various input and output devices as shown, including a display device 12 for outputting graphical images to the user, a keyboard 14 for providing character or toggle input from the user to the computer, and a touchpad 16 of the present invention. Display device 12 can be any of a variety of types of display devices; flat-panel displays are most common on portable computers. Display device 12 can display a graphical environment 18 based on application programs and/or operating systems that are running, such as a graphical user interface (GUI), that can include a cursor 20 that can be moved by user input, as well as windows 22, icons 24, and other graphical objects well known in GUI environments. 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.

Touchpad device 16 of the present invention preferably appears externally to be similar to the touchpads of the prior art. 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.

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 many 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.

Touchpad 16 preferably operates 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. 7. 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.

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. Preferably, the forces output on the touchpad are linear (or approximately linear) and oriented along the z-axis, approximately perpendicular to the surface of the touchpad 16 and the top surface of computer 10. In a different embodiment, forces can be applied to the touchpad 16 to cause side-to-side (e.g.,