inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

[0012] These and other advantages of the present invention will become apparent to those skilled in the art upon a reading of the following specification of the invention and a study of the several figures of the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a perspective view of a haptic touchpad of the present invention;

[0014] **FIG. 2** is a perspective view of a remote control device including the touchpad of the present invention;

[0015] **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;

[0016] **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;

[0017] **FIG. 5** is a side elevational view of a second embodiment of the touchpad of the present invention including a linear actuator;

[0018] **FIG. 6** is a side elevational view of a third embodiment of the touchpad of the present invention having an inertial mass;

[0019] **FIG. 7** is a top plan view of an example of a touchpad of the present invention having different control regions; and

[0020] **FIGS. 8***a* and **8***b* are top plan and side cross sectional views, respectively, of a touch screen embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] **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.

[0022] 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.

[0023] 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**.

[0024] 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 Ser. 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.

[0025] 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