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In another aspect of the present invention, a method for providing haptic feedback to a touch input device includes receiving a position signal from the touch input device indicating a contact location on a surface where said user is pressing, and determining in which of a plurality of regions on the surface the contact location is positioned. Force information is provided to cause an actuator to output a force to the user, the force associated with the user moving an object on or over the surface of the touch input device. A function can be associated with the region in which the contact location is positioned, such as rate control function of a value or moving a displayed cursor. The can be output when the user moves the object over a boundary to the contacted region from a different region of the touch input device.

The present invention advantageously provides haptic feedback to a planar touch control device of a computer, such as a touchpad or touch screen. The haptic feedback can assist and inform the user of interactions and events within a graphical user interface or other environment and ease cursor targeting tasks. Furthermore, the invention allows portable computer devices having such touch controls to take advantage of existing haptic feedback enabled software. The haptic touch devices disclosed herein are also inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

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

FIG. 1 is a perspective view of a laptop computer device including a haptic touchpad of the present invention;

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

FIG. 3 is a top plan view of a haptic touchscreen embodiment of the present invention;

FIG. 4 is a block diagram of a haptic system suitable for use in the present invention;

FIG. 5 is a perspective view of one embodiment of an actuator assembly suitable for use in an inertial embodiment of the present invention;

FIG. 6 is a perspective view of the actuator assembly of FIG. 5 coupled to a touchpad;

FIG. 7 is a perspective view of a separate palm surface providing inertial tactile sensations adjacent to a touchpad;

FIG. 8a is a perspective view of a piezoelectric transducer suitable for use in providing inertial sensations in the present invention;

FIG. 8b is a side elevational view of a piezoelectric transducer and structure of the present invention suitable for providing haptic sensations with a touch device;

FIG. 9 is a perspective view of one embodiment of a translating surface member driven by linear actuators;

FIG. 10 is a top plan view of another embodiment of a translating surface member driven by a rotary actuator;

FIG. 11 is a perspective view of another embodiment of a translating surface member driven by a voice coil actuator;

FIG. 12 is a perspective view of an embodiment of a translating surface adjacent to a touchpad;

FIG. 13 is a perspective view of an embodiment of a touchpad translated in one direction by a rotary actuator;

FIG. 14 is a perspective view of an embodiment of a touchpad translated in two directions by rotary actuators;

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FIGS. 15a and 15b are perspective views of a first embodiment of a flat E-core actuator of the present invention, suitable for translating a touchpad or a separate surface;

FIG. 15c is a side view of the actuator of FIGS. 15a-15b;

FIG. 15d is a perspective view of the actuator of FIGS. 15a-15b coupled to a touchpad;

FIGS. 16a and 16b are top and bottom perspective views of another embodiment of a flat E-core actuator of the present invention;

FIGS. 17a-17b are perspective and top views of surface-mounted E-core actuators of the present invention;

FIGS. 17c-17g are perspective and side views of the E-core actuators of FIGS. 17a-17b; and

FIG. 18 is a top plan view of an example of a haptic touchpad of the present invention having different control regions.

#### 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 can be 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 on the CPU of computer 10, 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 graphical environments or images may also be displayed, e.g. a game, movie or other presentation, spreadsheet or other application program, etc.

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. 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.