HAPTIC INTERFACE FOR LAPTOP COMPUTERS AND OTHER PORTABLE DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and is a continuation of U.S. patent application Ser. No. 09/917,263, filed Jul. 26, 2001 now U.S. Pat. No. 6,822,635, which is a continuation-in-part of U.S. patent application Ser. No. 09/487,737, filed on Jan. 19, 2000 and entitled, "Haptic Feedback for Touchpads and Other Touch Controls," now U.S. Pat. No. 6,429,846, and which claims the benefit of U.S. Provisional Patent Application No. 60/274,444, filed Mar. 9, 2001, and entitled, "Haptic Interface for Laptop Computers and Other Portable Devices," each of which is assigned to the assignee of the present application, and each of which is incorporated in its entirety herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates generally to the interfacing with computer and mechanical devices by a user, and more particularly to devices used to interface with computer systems and electronic devices and which provide haptic feedback to the user.

Humans interface with electronic and mechanical devices in a variety of applications, and the need for a more natural, easy-to-use, and informative interface is a constant concern. In the context of the present invention, humans interface with computer devices for a variety of applications. One such application is interacting with computer-generated environments such as games, simulations, and application programs. Computer input devices such as mice and trackballs are often used to control a cursor within a graphical environment and provide input in these applications.

In some interface devices, force feedback or tactile feedback is also provided to the user, collectively known herein as "haptic feedback." For example, haptic versions of joysticks, mice, gamepads, steeling wheels, or other types of devices can output forces to the user based on events or interactions occurring within the graphical environment, such as in a game or other application program.

In portable computer or electronic devices, such as laptop computers, mice typically too large a workspace to be practical. As a result, more compact devices such as trackballs are often used. Currently, a more popular device for portable computers are "touchpads," which are small rectangular, planar pads provided near the keyboard of the computer. The touchpad senses the location of a pointing object by any of a variety of sensing technologies, such as capacitive sensors or pressure sensors that detect pressure applied to the touchpad. The user contacts the touchpad most commonly with a fingertip and moves his or her finger on the pad to move a cursor displayed in the graphical environment. In other embodiments, the user can operate a stylus in conjunction with the touchpad by pressing the stylus tip on the touchpad, and moving the stylus.

One problem with existing touchpads is that there is no haptic feedback provided to the user. The user of a touchpad is therefore not able to experience haptic sensations that assist and inform the user of targeting and other control tasks within the graphical environment. The touchpads of the prior art also cannot take advantage of existing haptic-enabled software run on the portable computer.

SUMMARY OF THE INVENTION

The present invention is directed to a haptic feedback planar touch control used to provide input to a computer system. The control can be a touchpad provided on a portable computer, or can be a touch screen found on a variety of devices. The haptic sensations output on the touch control enhance interactions and manipulations in a displayed graphical environment or when controlling an electronic device.

More specifically, the present invention relates to a haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control. The control includes a touch input device including an approximately planar touch, surface operative to input a position signal to a processor of said computer based on a location of user contact on the touch surface. One or more actuators are coupled to the touch input device which can output a force to laterally move the touch input device approximately parallel to its surface to provide a haptic sensation to the user contacting it. The computer can position a cursor in a graphical environment displayed on a display device based on the position signal. The touch input device can be a separate touchpad or included as a touch screen. The user can contact the touch surface with a finger or other object, such as a stylus. Two actuators can move the touch input device in orthogonal directions parallel to the touch surface.

In another embodiment, a haptic feedback touch control for inputting signals to a computer and for outputting forces to a user includes a touch input device including an approximately planar touch surface which inputs a position signal to a computer processor, a surface member located adjacent to the touch input device, where the user can contact the surface when pressing the touch input device, and an actuator coupled to the surface member. The actuator outputs a force on the surface member to provide a haptic sensation to the user. The surface member can be translated laterally, approximately in a plane parallel to the surface of the touch input device; for example, the surface member can be positioned over the touch input device and approximately coextensive with the surface of the touch input device. Or, the surface member can be positioned to a side of the touch input device such that the user touches the touch input device with one finger and touches the surface member with a different finger or palm for example, the surface member can be positioned over a physical button that is located adjacent to said touch input device. Contact or inertial forces can be output on the surface member.

In another aspect of the present invention, an actuator providing a linear force output includes a ferromagnetic piece including a center pole located between two side poles, a coil wrapped around the center pole, a magnet adjacent to the center pole and side poles, and a backing plate coupled to the magnet, where the backing plate and magnet move with respect to the ferromagnetic piece when current is flowed in the coil. Rollers can be positioned between the ferromagnetic piece and backing plate to allow the motion. A flexure can reduce the relative motion between plate and ferromagnetic piece in undesired directions and provide a spring centering force.

In another aspect, a haptic touch device includes a piezoelectric transducer coupled to a ground and including a metal diaphragm coupled to a ceramic element and a planar sensing element, such as a touchpad. A spacer is provided between the piezoelectric transducer and the planar sensing element, the metal diaphragm contacting the spacer. A spring element provides a spring restoring force to the planar sensing element.