# HAPTIC FEEDBACK FOR TOUCHPADS AND OTHER TOUCH CONTROLS

## CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 10/615,986 entitled "Haptic Feedback for Touchpads and Other Touch Controls," filed Jul. 10, 2003, which is a continuation of U.S. Pat. No. 7,148,875, entitled "Haptic Feedback for Touchpads and Other Touch Controls," issued Dec. 12, 2006, which is a continuation of U.S. Pat. No. 6,429,846, entitled "Haptic Feedback for Touchpads and Other Touch Controls," issued Aug. 6, 2002, which is a continuation-in-part of U.S. Pat. No. 6,563,487, entitled "Haptic Feedback for Directional Control Pads," issued May 13, 2003, which is a continuation-in-part of U.S. Pat. No. 6,243,078, entitled "Low Cost Force Feedback Pointing Device," issued Jun. 5, 2001, which is a continuation-in-part of U.S. Pat. No. 6,184,868, entitled "Haptic Feedback Control Devices," issued Feb. 6, 2001, which is a continuation-in-part of U.S. Pat. No. 6,088,019, entitled "Low Cost Force Feedback Device with Actuator for Non-Primary Axis," issued Jul. 11, 2000.

## BACKGROUND OF THE INVENTION

[0002] 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.

[0003] 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.

[0004] 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, steering 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.

[0005] 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. A more popular device for portable computers are "touchpads," which are small rectangular, planar pads provided near the keyboard of the computer. The touchpads 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.

[0006] 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

[0007] 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.

[0008] 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. The computer positions a cursor in a graphical environment displayed on a display device based at least in part on the position signal. At least one actuator is also coupled to the touch input device and outputs a force on the touch input device to provide a haptic sensation to the user contacting the touch surface. The actuator outputs the force based on force information output by the processor to the actuator.

[0009] The touch input device can be a touchpad separate from a display screen of the computer, or can be included in a display screen of the computer as a touch screen. The touch input device can be integrated in a housing of the computer or handheld device, or provided in a housing that is separate from the computer. The user contacts the touch surface with a finger, a stylus, or other object. The force is preferably a linear force output approximately perpendicularly to a plane of the touch surface of the touch input device, and the actuator can include a piezo-electric actuator, a voice coil actuator, a pager motor, a solenoid, or other type of actuator. In one embodiment, the actuator is coupled between the touch input device and a grounded surface. In another embodiment, the actuator is coupled to an inertial mass, wherein said actuator outputs an inertial force on the touch input device approximately along an axis perpendicular to the planar touch surface. A touch device microprocessor separate from the main processor of the computer can receive force information from the host computer and provide control signals based on the force information to control the actuator.

[0010] The haptic sensations, such as a pulse, vibration, or spatial texture, are preferably output in accordance with an interaction of a controlled cursor with a graphical object in the graphical environment. For example, a pulse can be output when the cursor is moved between menu elements in a menu, moved over said icon, or moved over a hyperlink. The touch input device can include multiple different regions, where at least one of the regions provides the position signal and at least one other region provides a signal that is used by the computer to control a different function,