MULTI-TOUCH DISPLAY SCREEN WITH LOCALIZED TACTILE FEEDBACK

[0001] This application is a nonprovisional of U.S. Provisional Patent Application No. 61/009,615, filed Dec. 31, 2007, which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] This invention relates to a multi-touch display screen capable of providing localized tactile, or haptic, feedback to a user as the user navigates a touch-based user interface.

BACKGROUND OF THE INVENTION

[0003] Conventional touch pads, such as those used as mouse pads on laptop computers, require a user to view a separate display screen while interacting with the touch pad. Virtual buttons, icons and other textual and graphical display elements are presented to the user and, by moving a finger or stylus on the touch pad, the user can navigate a cursor and/or select various display elements.

[0004] Some display screens can also be used as a touch based input component. These touchscreens are capable of displaying various text and graphics to a user, which the user can select by touching the touchscreen. More specifically, touchscreens can be configured to display virtual buttons and other types of options to the user. The user may select a virtual button by tapping the portion of the touchscreen where the virtual button is being displayed. The locations, shapes and sizes of virtual buttons, unlike physical buttons, can be dynamic and change with each menu or display that is presented to the user. This allows the same physical space to represent different input elements at different times.

[0005] More recently, multi-touch display screens have been described and incorporated into handheld media players, such as Apple Inc.'s iPhone™. (Apple Inc. owns the iPhone™ trademark.) Multi-touch display screens are specialized touchscreens that can detect more than one simultaneous touch events in different locations on the touchscreen. With such devices, a user may move one or more fingertips across the touchscreen in a pattern that the device translates into an input command. The device may then respond accordingly. One pattern of finger movements (such as a pinching motion) may, for example, zoom in on a picture, while another pattern of finger movements (such as a reverse pinching) may zoom out.

[0006] Multi-touch display screens usually include a transparent touch panel and visual display component. The touch panel comprises a touch sensitive surface and is often positioned in front of the display screen. In this manner, the touch sensitive surface covers the viewable area of the display screen and, in response to detecting a touch event, generates a signal that can be processed and utilized by other components of the electronic device. Multi-touch display screens are discussed in more detail in commonly assigned U.S. Patent Publication No. US 2006/0097991, entitled "MULTIPOINT TOUCHSCREEN," which is incorporated by reference herein in its entirety.

[0007] However, one of a touchscreen's biggest advantages (i.e., the ability to utilize the same physical space for different functions) is also one of a touchscreen's biggest disadvantages. When the user is unable to view the display (because the user is occupied with other tasks), the user can only feel the smooth, hard surface of the touchscreen, regardless of the shape, size and location of the virtual buttons and/or other display elements. This makes it difficult for users to find icons, hyperlinks, textboxes, or other user-selectable input elements that are being displayed, if any are even being displayed, without looking at the display. But, in some instances, it may be inconvenient, or even dangerous, for the user to look at the display. Unless touch input components are improved, users that, for example, drive a motor vehicle, may avoid devices that have a touch input component and favor those that have a plurality of physical input components (e.g., buttons, wheels, etc.). The present invention improves on nearly all kinds of touch input components that are used in conjunction with a display screen.

SUMMARY OF THE INVENTION

[0008] The present invention includes systems, methods, computer readable media and other means for providing localized tactile, or haptic, feedback to a user of a touchscreen electronic device. The haptic feedback can take any form, including vibration, and can be paired with other non-visual feedback such as audible noise. The present invention may utilize a grid of piezoelectric actuators to provide haptic feedback that enables a user to non-visually navigate a visual display.

[0009] In some embodiments of the present invention, a user input component includes a touch-sensitive surface and a grid of piezoelectric actuators. The grid of piezoelectric actuators may be transparent or opaque. An individual piezoelectric actuator can be activated by applying control signals to its top and bottom electrodes. In some embodiments, the actuators may share a common electrode in the form of a backplane.

[0010] In some embodiments of the present invention, the user input component can be integrated into an electronic device having a display screen. For example, the user input component can be used and/or integrated into any type of electronic device, including laptop computers, cellular telephones, and portable media devices. The present invention may also utilize a user input component integrated with a display screen, such as a touchscreen.

[0011] The display screen can be used to present a visual display which includes a virtual button. A haptic feedback response can be associated with the virtual button. The haptic feedback response can be provided while the virtual button is included in the visual display, or in response to a touch event. For example, the virtual button can vibrate when a touch event occurs in proximity to the virtual button. In addition to virtual buttons, the display can include other user-selectable display elements.

[0012] For example, the visual display can include a virtual click wheel associated with a haptic feedback response. For example, the virtual button at the center of the virtual click wheel can vibrate at a different frequency than the virtual wheel surrounding it. The virtual wheel and the virtual button at the center can vibrate while they are included in the visual display, or in response to a touch event. By providing dynamic, localized, haptic feedback at the location of the