

pared to the touch and display pixels, i.e., multiple pixels can be situated within the area of a node. The resolution can be dependent on the desired needs of the device. In some embodiments, the touch sensing nodes can be spaced apart and placed between shape changeable nodes. In some embodiments, the touch sensing nodes can cover the entire surface including portions of the shape changeable nodes.

[0083] FIG. 4 illustrates an exemplary user interface that can physically change topography using various modules according to embodiments of the invention. The user interface 40 can for example be associated with the user interfaces 10, 20, 30 shown in FIGS. 1 through 3 respectively. The user interface can be associated with an input/output device that can be operatively coupled to a host device. The host device can for example be an electronic device, such as a portable computer, or a handheld electronic device, such as a phone or media player. Generally speaking, the user interface can be applied to a consumer electronic product that includes a user interface. In some cases the user interface can be peripherally operable relative to the host, while in other cases the user interface can be integrated within the host. The user interface can be particularly useful in portable devices and further handheld devices that can have limited real estate for placement of a user interface. By way of example, the user interface can be integrated within a touch screen of an iPhone™ or touch pad of an iPod™ manufactured by Apple Inc. of Cupertino, Calif.

[0084] In the example of FIG. 4, the user interface 40 can include shape changeable layer 41 to change topography of the user interface. The shape changeable layer 41 can for example include a matrix of nodes, each of which can be capable of physically changing a specific location of the user interface in order to change the topography of the surface. For example, each shape changeable node can be configured to raise or lower the surface of the user interface, thereby changing the topography. This can be done in with multiple nodes in combination or with discrete single nodes. That is, the nodes can be controlled in a variety of ways to produce the desired topography, i.e., different shapes, contours, forms.

[0085] The user interface 40 can also include sensing layer 45 to detect a touch or near touch (proximity). Like the shape changeable layer, the sensing layer can include a matrix of nodes. The sensing nodes can be configured to detect the presence of an object such as a finger. The sensing layer 45 can be widely varied. In one example, the sensing layer 45 can be based on capacitance. It should be appreciated that other technologies including resistive, surface wave, pressure sensing and the like can be used. In some cases, the sensing layer 45 can even be multipoint sensing, i.e., capable of sensing multiple objects at the same time (simultaneously). In one example, the sensing layer 45 can be associated with touch sensing (or near touch/proximity). The sensing nodes can be configured to cooperate with the shape changeable nodes to change the topography and sensing areas of the user interface. For example, while the shape changeable nodes can alter the shape of the user interface, the sensing nodes can alter the detectable areas of the user interface. In one example, the sensing nodes can be activated or deactivated and the shape changeable nodes can be adjusted based on the desired user interface.

[0086] The user interface 40 can also optionally include display layer 46 to display user interface elements as for example when the user interface 40 is associated with a touch screen. The display layer 46 can be configured to display

graphics and text. The display layer 46 can be a single display or a group of displays that work together. When discrete, the displays can work with the shape changeable nodes to change the topography of the user interface. For example, the displays can raise or lower. In some cases, the display layer 46 can be unassociated from a touch screen and can work with shape changeable nodes independent of a touch sensor. For example, the display layer can change its topography based on what is being displayed to create a three-dimensional display effect.

[0087] The display layer can also be associated with a touch pad having a visual feedback elements as disclosed in U.S. patent application Ser. No. 11/394,493, entitled "Illuminated Touchpad," and Ser. No. 11/591,752, entitled "Touch Pad with Symbols Based on Mode," the contents of which are incorporated herein by reference in their entirety for all purposes.

[0088] The user interface 40 can also include controller module 42 for controlling the various layers of the user interface. The controller 42 can be, for example, a dedicated processor or a supplemental processor. The controller 42 can even be a part of the host device in some circumstances. The controller 42 can be in the form of an application specific integrated circuit (ASIC). In some cases, the controller 42 can include modules as for example shape module 42-a to control topographical changes, touch module 42-b to control touch detection, and optionally display module 42-c to control displays. The modules can be discrete or integrated, depending on the needs of the user interface.

[0089] In some cases, the user interface 40 can also include user interface state module 43 that can drive the user interface to change topography, display and/or sensing based on a desired user interface state. The user interface state module 43 can be part of the user interface 40 or separate. For example, the user interface state module can be associated with the host device. The module 43 can be, for example, software, firmware, or hardware. At various times, the controller 42 can drive the user interface to change topography. It is to be understood that other and/or additional components can comprise the user interface according to the needs of the user interface.

[0090] During operation, the controller 42 can be configured to control the various layers 41, 45, 46 in order to produce the desired user interface effect. For example, the shape changeable layer 41 can be controlled to produce a desired topography or to change the tactile feel of the user interface during use. In addition, the controller 42 can activate and deactivate touch regions. For example, the controller 42 can produce active regions that detect touches and null regions that ignore touches. In addition, the controller 42 can direct the display layer 46 to display user interface elements. For example, the controller 42 can instruct the display layer 46 to display virtual buttons or the like. It should be appreciated that the shape points or regions, touch points or regions and display points or regions can be controlled together to produce the desired user interface effect. In one embodiment, these elements can be associated with one another. For example, the display can display a virtual button, the touch sensor can be active at the virtual button, and the shape change can create boundaries around the virtual button or raise and/or lower the virtual button itself. The user can therefore feel and see the button and touch it to activate an input.

[0091] In some embodiments, the controller 42 can adjust each of the layers 41, 45, 46 in order to produce layouts based