processing unit (CPU). The CPU then activates the actuator for physically vibrating or pulsing the electronic device in which the touchscreen and LCD are contained. The physical movement of the electronic device provides tactile feedback to the user for indicating that an input to the touchscreen has been made. The actuator can include a vibrating motor, solenoid and other mechanical means for providing different types of physical movement.

[0020] **FIG. 1** is a block diagram for a force feedback system **10** with a touchscreen and LCD user interface according to an embodiment of the present invention. Examples of such electronic devices include PDA's, mobile communication devices such as cellular phones, and Blackberry™ communication devices. A force feedback system **10** includes a touchscreen **12**, an LCD **14**, a touchscreen controller **16**, a controller such as CPU **18**, an LCD controller **20** and an actuator **22**. The touchscreen **12** is a transparent layer that is placed over LCD **14**, and may be but are not limited to a resistive or a capacitive type. Resistive touchscreens use a thin membrane over the glass of an LCD so that when the membrane is touched, the touchscreen controller measures the resistance at the point of touch and computes the x-y coordinates. Capacitive touchscreens use a thin transparent conductive membrane over the surface of the glass on an LCD which forms an x-y grid of conductors. When the overlay is touched with a finger, capacitive coupling exists between the x and y conductors at the point of contact. The location of this coupling is measured by scanning the x and y conductors.

[0021] The touchscreen **12** provides electrical signals corresponding to the x-y coordinates at the location where the touchscreen has been touched. The touchscreen controller **16** decodes the electrical signal received from the touchscreen **12**, and provides touchscreen data to the CPU **18**. The CPU **18** provides display data to the LCD controller **20**, which drives the LCD **14** to display graphical information such as text or graphical buttons enclosing text, for example. The actuator **22** is controlled by the CPU **18** via actuator control signals for providing force feedback to the user. Preferably, the actuator comprises a vibrating motor. Motors for vibrating are well known in the art, and therefore do not require further discussion.

[0022] The operation of the tactile feedback electronic device **10** of **FIG. 1** is now described. When the user makes contact with the touchscreen **12**, the touchscreen controller **16** sends touchscreen data corresponding to the electrical signals received from the touchscreen to the CPU **18**. The CPU **18** then generates actuator control signals to activate, or turn on, the actuator **22** for a predetermined amount of time within the device in order to generate a tactile response that reflects what the user is doing on the screen. For example, if the user pressed on a button as it appeared on the LCD **14**, the response may feel like a click. Another possible input example would be the user sliding a finger along a scrolling bar on the LCD **14**, for which the response might be a vibration that diminishes or increases in intensity as the user slides a finger along the bar. The tactile responses that can be generated are numerous and are not limited to the previous two examples. The CPU **18** will also send display data to the LCD controller **20**, which controls the necessary graphical changes to the LCD **14** to visually confirm the user's input, or to request additional input from the user.

[0023] It should be apparent to those skilled in the art that the motor **22** in **FIG. 1** is an illustrative example of a possible actuator for providing force feedback. Other actuators configured to produce tactile, or force, feedback in response to user inputs will be obvious and thus within the scope of the present invention. The particular actuators implemented in the device may depend on the available physical space on or within the device, the types of feedback to be provided, or perhaps the presence of other actuators for other purposes such as notifying a user of an appointment, receipt of a new message and the like. It is also contemplated that multiple actuating devices may be implemented in any device. For example, each actuating device can vibrate the electronic device in different directions and in different combinations to provide tactile information. While a vibrating motor can be used to provide tactile feedback in the system of **FIG. 1, a** solenoid can be implemented in the same device to provide a mechanical pulse, or "click" feedback when a user presses a button on the touchscreen.

[0024] **FIG. 2** is a flow diagram describing a method for providing tactile feedback for the tactile feedback electronic device **10** of **FIG. 1**. The process begins in step **30**, where the device operating system (OS) waits for an input event. This can be done by driving the LCD with display data to visually prompt the user to make an input, for example. In step **32**, the user makes an input by touching the touchscreen **12**. Electrical signals are received by the touchscreen controller **16** and decoded into touchscreen data representing the x-y coordinates of the area where the touchscreen was touched. The touchscreen controller **16** sends the touchscreen data to the CPU **18** at step **34**. In step **36**, the CPU **18** processes the touchscreen data and generates actuator control signals to turn on the actuator **22** and generate a tactile response to reflect the event (input) that was generated by the user. The CPU **18** then sends display data to the LCD controller **20** to change the graphical information displayed on the LCD **14** to reflect the event generated by the user. This graphical information is changed by driving the LCD with new display data. If the user is required to make another input, as determined at step **38**, the user is prompted to do so via the information displayed on the LCD **14**, and the process returns to step **32**. If the user is not required to make another input, the process will return to step **20** and the device waits for another input event.

[0025] Therefore, the tactile feedback electronic device according to the embodiments of the present invention can improve the efficiency of use of the electronic device by physically validating touchscreen inputs to the user.

[0026] Although a CPU-based system is illustrated in the preferred embodiment of the present invention, specialized micro-controllers and other highly integrated controllers such as application specific integrated circuits (ASIC) can be used in place of the separate CPU, LCD controller and touchscreen controller implementation shown in **FIG. 1**. In other words, an ASIC device can integrate CPU functionality with the LCD and touchscreen controller functionality on a single chip. Such an alternate embodiment will occupy less board space in the device and allow more components to be placed within the device. In another alternate embodiment, the controller, or CPU **18** is pre-programmed with different types of vibrating modes. Hence the touchscreen data can be processed to generate the corresponding type of vibration. For example, the actuator can be pulsed or the