This can be useful in many ATM applications since there is not a cursor that is moved; haptic feedback can thus be useful to indicate to the user that a button has been pressed, e.g. a small vibration is output when a button is activated. Haptic feedback may also assist users in noisy environments, such as in areas with high vehicular traffic, where sound may not be easily heard by the user.

[0179] The embodiments described herein can also provide haptic feedback in an embodiment where the user is using a stylus or other object to input data on the touchpad, touch screen, or input area. The haptic sensations can be transmitted to the user from the touchpad (or other moving surface) and through the stylus or other object.

Other Features

[0180] A human factor issue related to haptic feedback in some embodiments may include force overload protection. Ideally, for non-inertial feedback actuators and transmission designs such as the translating surfaces and differential surfaces, it is desired for the actuator to produce large forces with fidelity regardless of the load on the actuator or the position within the actuator travel. Put another way, the finger or hand of the user should not move the actuator against a limit or reach an end of travel condition where half of a vibration cycle is attenuated. For this reason, it is desirable to design actuator and transmission mechanisms that are inherently decoupled from the user loading. An example of this would be an E-core actuator with very high spring centering provided by a stiff suspension, as in the embodiment of **FIG. 16*a*-16*b***. A forceful actuator can overcome this spring force easily, and the forces of a finger dragging on a touchpad surface are a small percentage of full scale actuator output. A weaker actuator may require a more compliant suspension, and this would allow the user interaction to interfere with oscillations and create non-linear output.

[0181] Another human-factor-related issue with haptic feedback in some embodiments can be audibility. The use of palm rest surfaces and inertial actuator assemblies, for example, causes sound that is the unavoidable side effect of a haptic sounding board. Loaded surfaces, such as when the user is touching the housing or touchpad, radiate sound poorly, and still transmit forces quite well. Thus, in some embodiments, a load measuring device can be used to determine when the user's hands are present on moving surfaces to allow forces to be output only when such hands are present.

[0182] To save costs when providing haptic functionality to a laptop touchpad or other similar input device, the existing sound electronics within the laptop, PDA, or other device can be utilized in some embodiments. For example, the existing sound analog output (e.g. digital-to-analog converter) and the sound power amplifiers can drive the actuator used for haptic feedback for the touchpad or other laptop component as described above, without having to add an additional microprocessor and/or additional power electronics. A notch filter or other pickoff from the sound signal can be used to provide the haptic feedback signal. For example, haptic effect control signals can be provided in the inaudible range of the sound spectrum and filtered so that these control signals can be provided to the haptic actuator, while the remainder of the signal in the audible range is routed to the audio speakers of the laptop. Or, dedicated signals that are outside the audible range and not included with audio signals can be filtered or routed to control the haptic feedback actuator(s).

[0183] Furthermore, existing software on many laptops tracks the battery power for the laptop to indicate power level, warn the user, or shutoff the laptop to conserve battery power. This tracking software can be tapped into for haptic feedback applications. For example, if battery power gets below a certain level, the haptic feedback software routines can scale down or even turn off the output forces to the user. This can be accomplished by dropping the magnitude of the forces, or by reducing the types or number of graphical objects in the GUI that have haptic effects associated with them. This can also be accomplished by shortening the duration of haptic effects, e.g. effects that are normally 50 ms can be reduced to 40 ms, etc. Also, a combination of such methods can be used. Finally, some laptop computers have different settings, such as high power, medium power, and low power, which a user can select according to his or her needs, e.g. lower power setting allows the batteries to last longer. The haptic feedback control can link into the setting and be governed by this setting as well. For example, if the user selects low power mode, the haptic feedback controller can adapt as described above to reduce power requirements of the haptic effects.

[0184] **FIG. 18** is a top elevational view of a touchpad **450** of the present invention. Touchpad **450** can in some embodiments be used simply as a positioning device, where the entire area of the touchpad provides cursor control. In other embodiments, different regions of the pad can be designated for different functions. In some of these region embodiments, each region can be provided with an actuator located under the region or otherwise physically associated with the region, while other region embodiments may use single actuator that imparts forces on the entire touchpad **450**. In the embodiment shown, a central cursor control region **452** can be used to position a cursor or viewpoint displayed by the laptop computer or other device.

[0185] The cursor control region of a touchpad can cause forces to be output on the touchpad based on interactions of the controlled cursor with the graphical environment and/or events in that environment. The user moves a finger or other object within region **452**, for example, to correspondingly move the cursor **20**. Forces are preferably associated with the interactions of the cursor with displayed graphical objects. For example, a jolt or "pulse" sensation can be output, which is a single impulse of force that quickly rises to the desired magnitude and then is turned off or quickly decays back to zero or small magnitude. The touchpad **450** can be jolted in one direction or as an oscillation in the z-axis or other axis inertially in the inertial haptic feedback embodiments, or the touchpad can be translated in one direction or oscillated one or more times to provide the pulse. A vibration sensation can also be output, which is a time-varying force that is typically periodic. The vibration can cause the touchpad **450** or portions thereof to oscillate back and forth multiple times, and can be output by a host or local microprocessor to simulate a particular effect that is occurring in a host application.

[0186] Another type of force sensation that can be output on the touchpad is a texture force. This type of force is