input device while touching it and that relative pressure may also be used for control and may be used at least in part to create haptic output to the user.

[0010] 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 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. The actuator may be coupled to cause relative movement between a display screen and a transparent touch input panel disposed over the display screen in a touch screen device. A touch device microprocessor which may be 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.

[0011] The haptic sensations, such as a pulse, vibration, or spatial texture, may be output in accordance with an interaction between a user controlled location and a graphical object in the graphical environment. 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, such as rate control function of a value or a button press. Different regions and borders between regions can be associated with different haptic sensations. Alternatively, rate control may be established through a magnitude of the touch force applied by the user. For example, more force could be used to increase the rate input and less force could be used to decrease it.

[0012] The present invention advantageously provides haptic feedback to a planar touch control device of a computer, such as a touchpad or touch screen. The haptic feedback can assist and inform the user of interactions and events within a graphical user interface or other environment and ease cursor targeting tasks. Furthermore, the invention allows portable computer devices having such touch controls to take advantage of existing haptic feedback enabled software. The haptic touch devices disclosed herein may also be produced so that they are inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

[0013] These and other advantages of the present invention will become apparent to those skilled in the art upon a reading of the following specification of the invention and a study of the several figures of the drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings, which are incorporated into and constitute a part of this specification, illustrate one or more embodiments of the present invention and, together with the detailed description, serve to explain the principles and implementations of the invention.

[0015] In the drawings:

[0016] **FIG. 1** is a perspective view of a haptic touchpad of the present invention;

[0017] **FIG. 2** is a perspective view of a remote control device including the touchpad of the present invention;

[0018] **FIG. 3** is a perspective view of a first embodiment of the touchpad of the present invention including one or more actuators coupled to the underside of the touchpad;

[0019] **FIG. 4** is a side elevational view of a first embodiment of the present invention in which a piezo-electric actuator is directly coupled to the touchpad of the present invention;

[0020] **FIG. 5** is a side elevational view of a second embodiment of the touchpad of the present invention including a linear actuator;

[0021] **FIG. 6** is a side elevational view of a third embodiment of the touchpad of the present invention having an inertial mass;

[0022] **FIG. 7** is a top plan view of an example of a touchpad of the present invention having different control regions;

[0023] **FIGS. 8A and 8B** are top plan and side cross sectional views, respectively, of a touch screen embodiment of the present invention;

[0024] **FIG. 9** is a plot of force versus position illustrating a force profile typical of a conventional snap-type button;

[0025] **FIG. 10** is a plot of push button force versus push button displacement illustrating hysteresis in a typical push button;

[0026] **FIG. 11** is a plot illustrating a combined sawtooth waveform;

[0027] **FIG. 12** is a plot illustrating a single pulse waveform in one direction on press down (left plot) followed by a single pulse in the opposite direction on press up (right plot);

[0028] **FIG. 13** is a plot of a sawtooth type of single discontinuity waveform;

[0029] **FIG. 14** is a diagram of a screen image showing a scroll bar;

[0030] **FIG. 15** is a flow diagram showing a method for simulating a button press using haptic feedback imparted through a touch surface;

[0031] **FIG. 16** is a flow diagram showing a method for providing haptic feedback representative of the extent to which an action triggered by manipulation of a cursor relative to a graphical object displayed on a display screen is occurring;

[0032] **FIG. 17**. is a perspective view of video poker game using a slider switch having haptic feedback;

[0033] **FIG. 18** is a flow diagram showing a method for providing haptic feedback in response to a manipulation of a graphical object;

[0034] **FIG. 19** is a flow diagram showing a method for providing haptic feedback representative of the relative location of a cursor and a graphical object displayed on a display screen;

[0035] **FIG. 20** is an elevational diagram illustrating an actuator for providing haptic effects in accordance with one embodiment of the present invention;