a feedback circuit operatively connected to said user input device and said processor, said feedback circuit produces a sound effect indicating degree of the rotational action with respect to said user input device.

36. A portable media player as recited in claim 35, wherein the sound effect is electrically induced by said feedback circuit.

37. A method for displaying a portion of a list of media items on a display of a media player, the media player having a rotational input device, said method comprising:

(a) determining a rate of turn of the rotational input device;

(b) obtaining a length of the list of media items;

(c) determining a next portion of the list of media items to be displayed based on the rate of the turn of the rotational input device and the length of the list of media items; and

(d) displaying the next portion of the list of media items.

38. A method as recited in claim 37, wherein the number of media items that can be display on the display at any one time is limited due to the small size of the display.

39. A method as recited in claim 37, wherein the next portion does not consecutively follow a former portion when the rate of turn of the rotational input device exceeds a threshold rate.

40. A method as recited in claim 37, wherein the next portion includes a plurality of the media items from the list of media items.

41. A method as recited in claim 37, wherein the rotational input device is a navigation wheel.

42. A method as recited in claim 37, wherein the media items are audio files.

43. A method as recited in claim 37, wherein the media player is a MP3 player.

44. A method as recited in claim 37, wherein said method further comprises:

(e) providing audible feedback.

45. A method as recited in claim 44, wherein the audible feedback is dependent on the rate of turn of the rotational input device.

46. A method for displaying a portion of a list of items on a display of a computing device, the computing device having a rotational input device, said method comprising:

(a) determining an indication of turning of the rotational input device;

(b) determining a next portion of the list of items to be displayed based on the indication of turning of the rotational input device; and

(c) displaying the next portion of the list of items.

47. A method as recited in claim 46, wherein the indication of turning of the rotational input device comprises a rate of turn of the rotational input device.

48. A method as recited in claim 46, wherein the rotational input device is a navigation wheel.

49. A method as recited in claim 46, wherein the computing device is a media player, and wherein the items are media items.

50. A method as recited in claim 49, wherein the media player is a portable media player.

51. A method as recited in claim 49, wherein the media player is a MP3 player.

52. A method as recited in claim 49, wherein the media items are audio files for songs.

53. A method as recited in claim 49, wherein said method further comprises:

(e) providing audible feedback.

54. A method as recited in claim 46, wherein said method further comprises:

(e) providing audible feedback.

55. A method as recited in claim 46, wherein said determining (b) of the next portion of the list of items is based on the indication of turning of the rotational input device and a predetermined value.

56. A method as recited in claim 55, wherein the predetermined value is a chunking value.

57. A consumer electronics product, comprising:

a storage disk that stores a plurality of media items;

a display for displaying a first portion of the plurality of media items;

a user input device that enables a user of said consumer electronics product to at least scroll through a list of the plurality of media items in accordance with a user-controlled scroll rate; and

a processor operatively connected to said storage disk, said display, and said user input device, said processor determines an acceleration factor for use in scrolling the list of the plurality of media items and causes said consumer electronics product to display a second portion of the plurality of media items, the location of second portion of the plurality of media items within the list of the plurality of media items being dependent on at least the user-controlled scroll rate and the acceleration factor.

58. A consumer electronics product as recited in claim 57, wherein said consumer electronics products is a portable, battery-operated media player.

59. A consumer electronics product as recited in claim 58, wherein the media player is an MP3 player, and wherein the media items are audio files for songs.

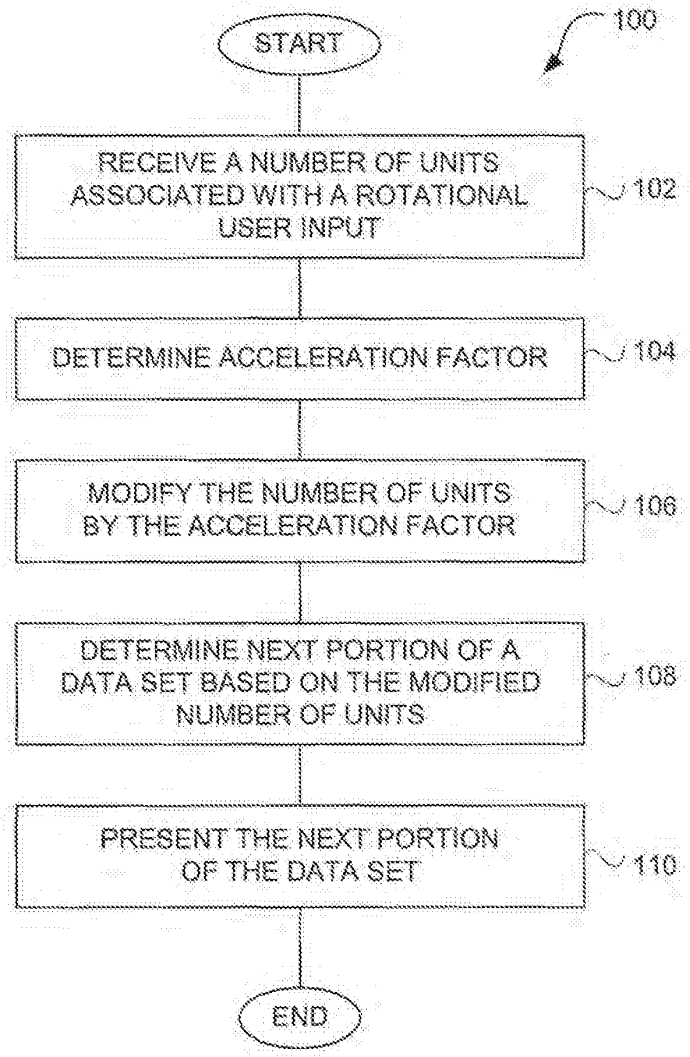

START
100
RECEIVE A NUMBER OF UNITS ASSOCIATED WITH A ROTATIONAL USER INPUT
102
DETERMINE ACCELERATION FACTOR
104
MODIFY THE NUMBER OF UNITS BY THE ACCELERATION FACTOR
106
DETERMINE NEXT PORTION OF A DATA SET BASED ON THE MODIFIED NUMBER OF UNITS
108
PRESENT THE NEXT PORTION OF THE DATA SET
110
END

FIG. 1

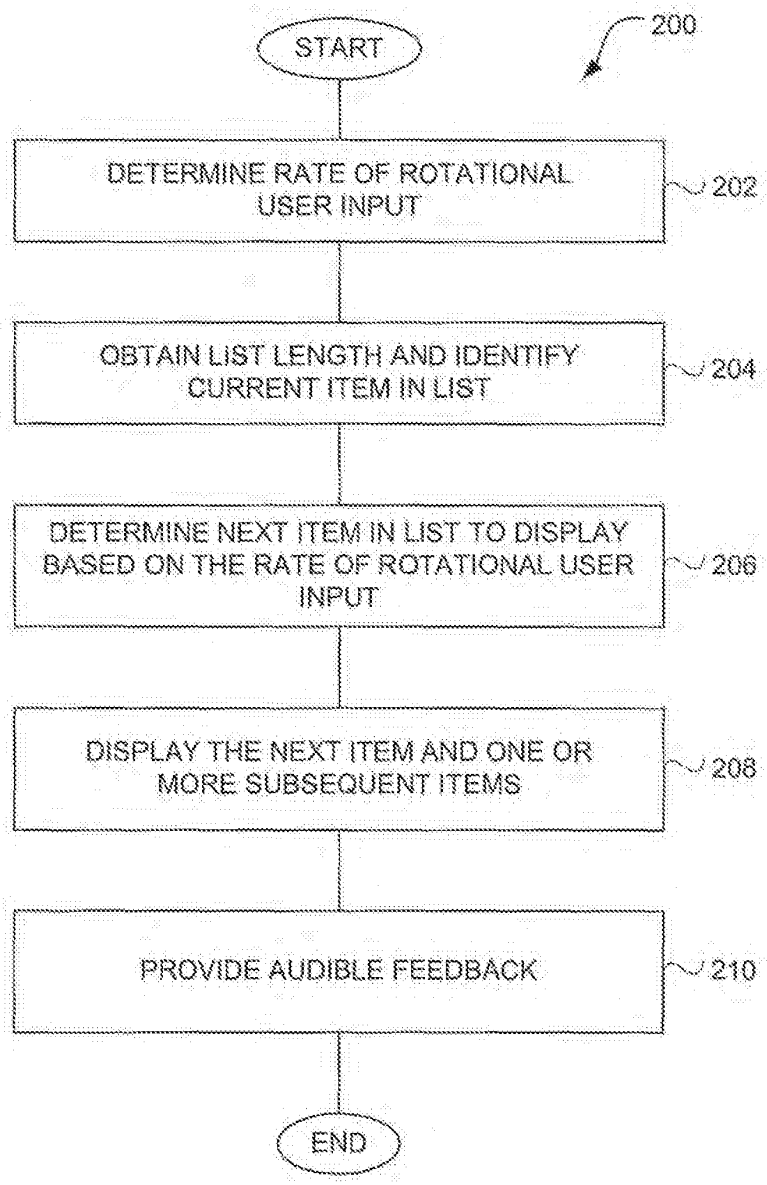

START
200
DETERMINE RATE OF ROTATIONAL USER INPUT
202
OBTAIN LIST LENGTH AND IDENTIFY CURRENT ITEM IN LIST
204
DETERMINE NEXT ITEM IN LIST TO DISPLAY BASED ON THE RATE OF ROTATIONAL USER INPUT
206
DISPLAY THE NEXT ITEM AND ONE OR MORE SUBSEQUENT ITEMS
208
PROVIDE AUDIBLE FEEDBACK
210
END

FIG. 2

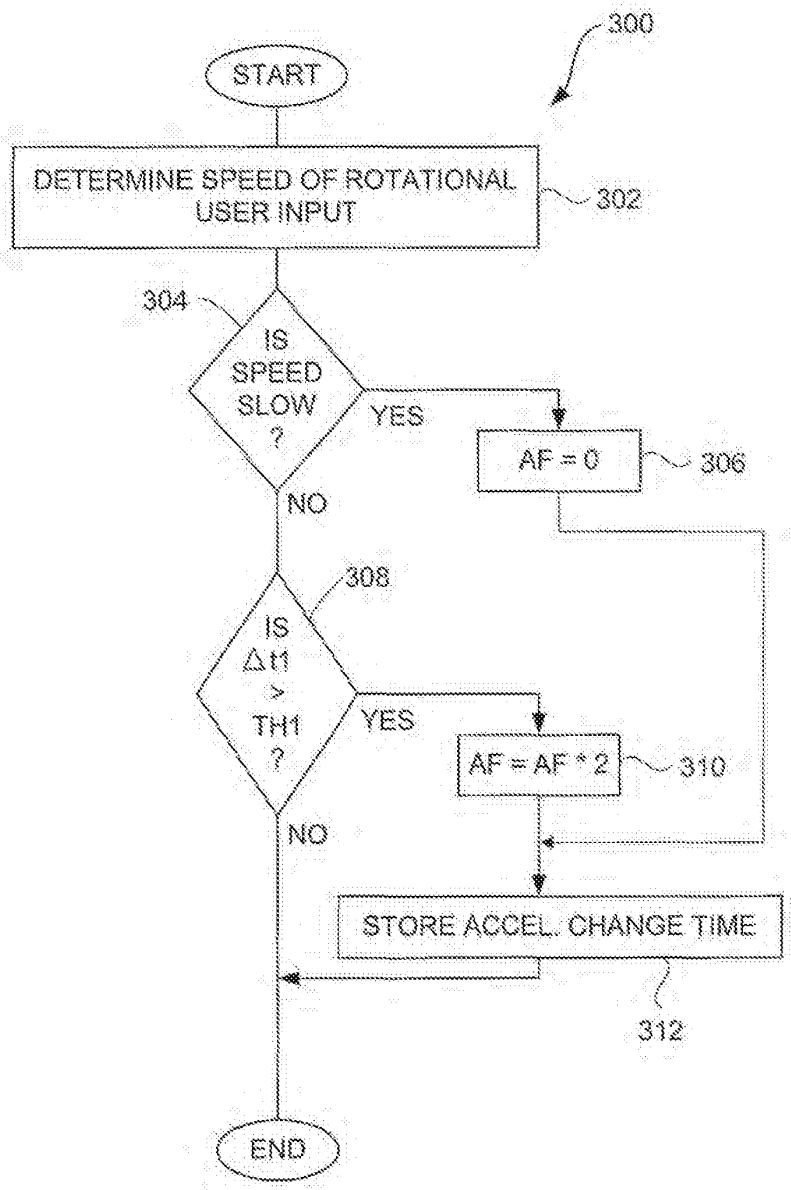

300
START
DETERMINE SPEED OF ROTATIONAL USER INPUT
302
304
IS SPEED SLOW ?
YES
AF = 0
306
NO
308
IS Δt1 > TH1 ?
YES
AF = AF * 2
310
NO
STORE ACCEL. CHANGE TIME
312
END

FIG. 3

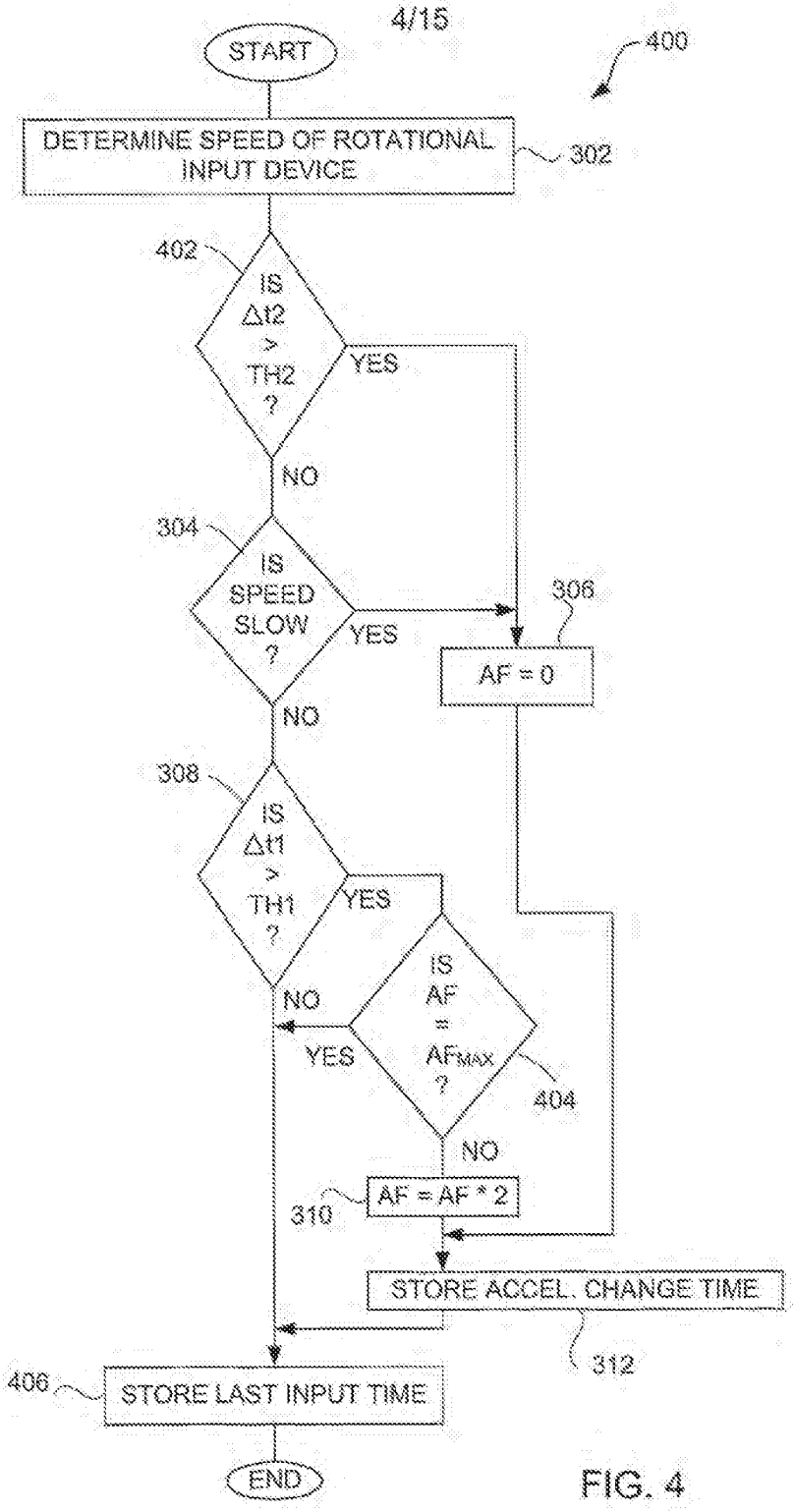

START
400
DETERMINE SPEED OF ROTATIONAL INPUT DEVICE
302
402
IS Δt2 > TH2 ?
YES
NO
304
IS SPEED SLOW ?
YES
306
AF = 0
NO
308
IS Δt1 > TH1 ?
YES
NO
IS AF = AFMAX ?
YES
404
NO
310
AF = AF * 2
STORE ACCEL. CHANGE TIME
312
406
STORE LAST INPUT TIME
END

FIG. 4

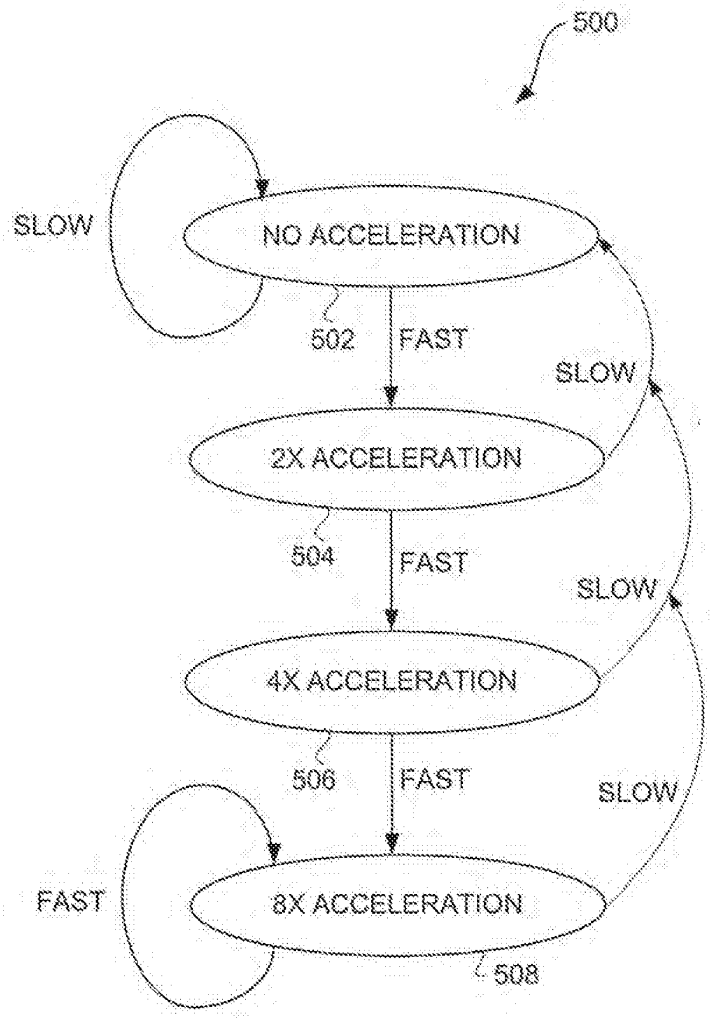

500
SLOW
NO ACCELERATION
502
FAST
SLOW
2X ACCELERATION
504
FAST
SLOW
4X ACCELERATION
506
FAST
SLOW
FAST
8X ACCELERATION
508

FIG. 5

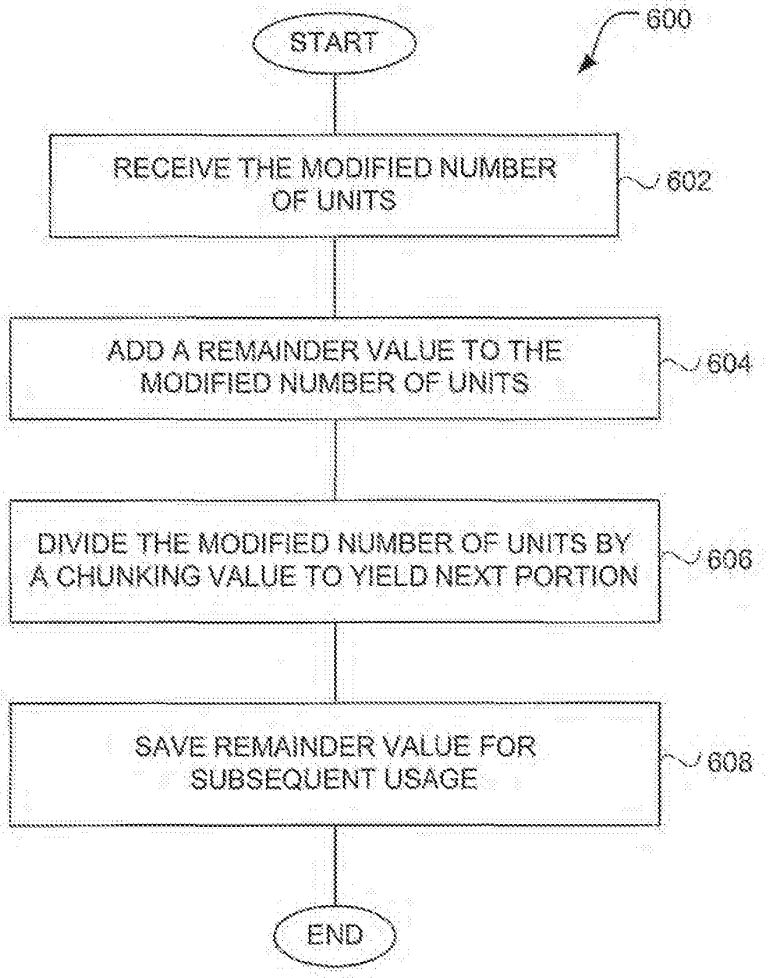

START
600
RECEIVE THE MODIFIED NUMBER OF UNITS
602
ADD A REMAINDER VALUE TO THE MODIFIED NUMBER OF UNITS
604
DIVIDE THE MODIFIED NUMBER OF UNITS BY A CHUNKING VALUE TO YIELD NEXT PORTION
606
SAVE REMAINDER VALUE FOR SUBSEQUENT USAGE
608
END

FIG. 6

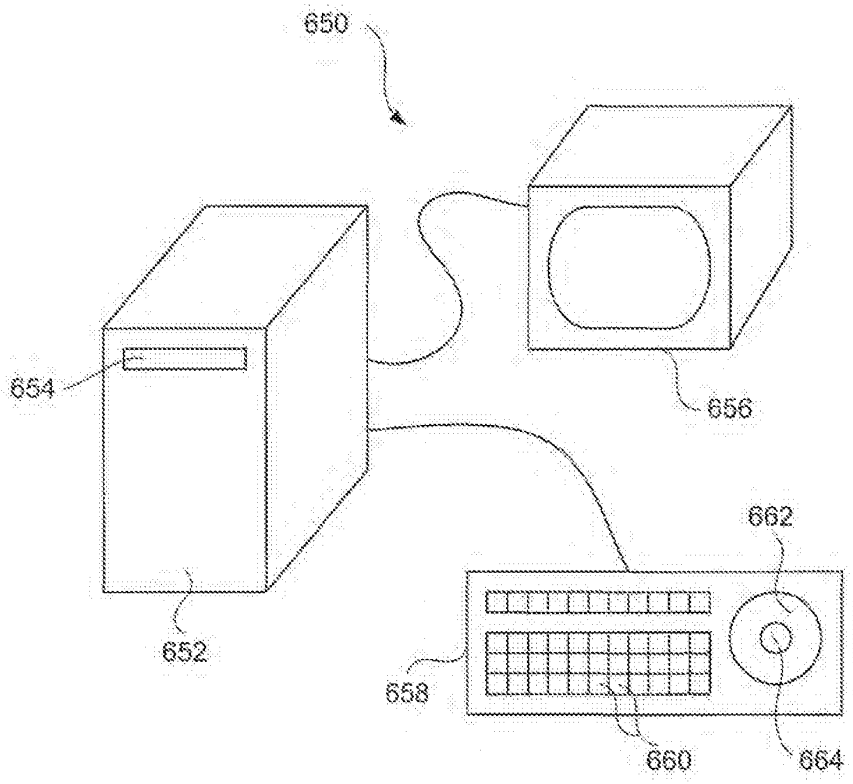


FIG. 7A

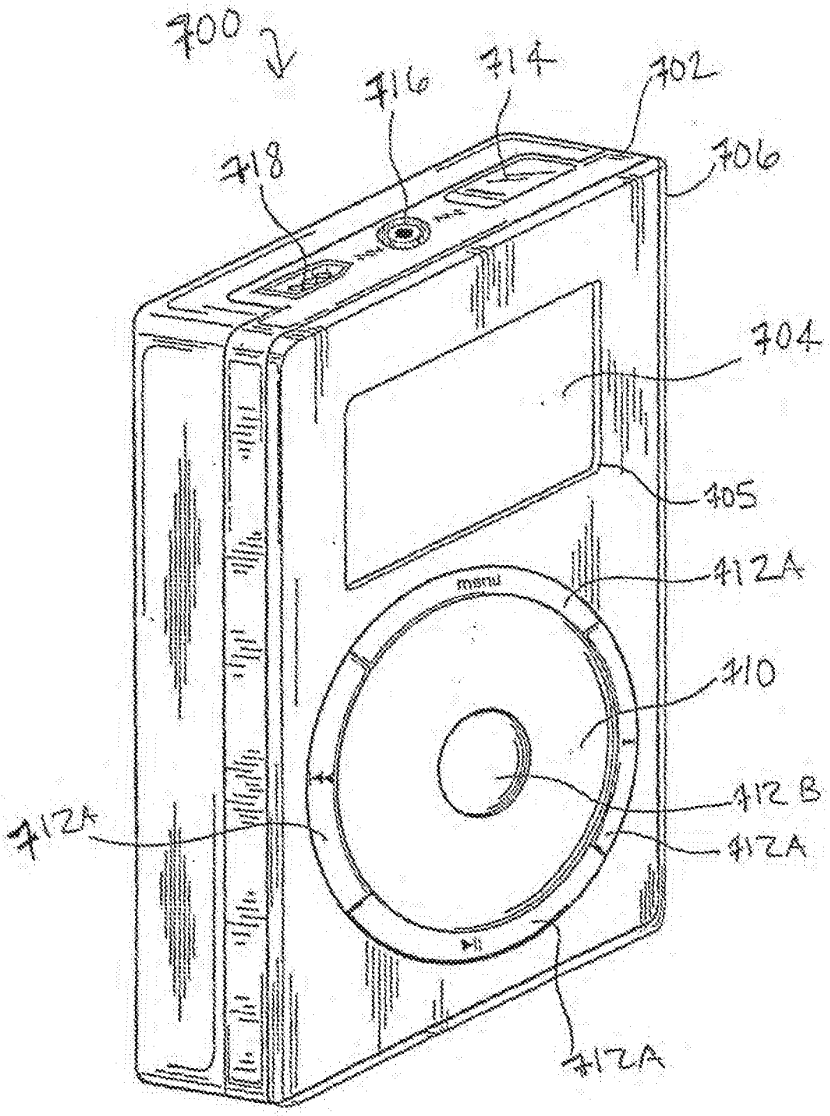

700
716
714
702
718
706
704
405
412A
menu
410
412B
412A
412A
412A

FIG. 7B

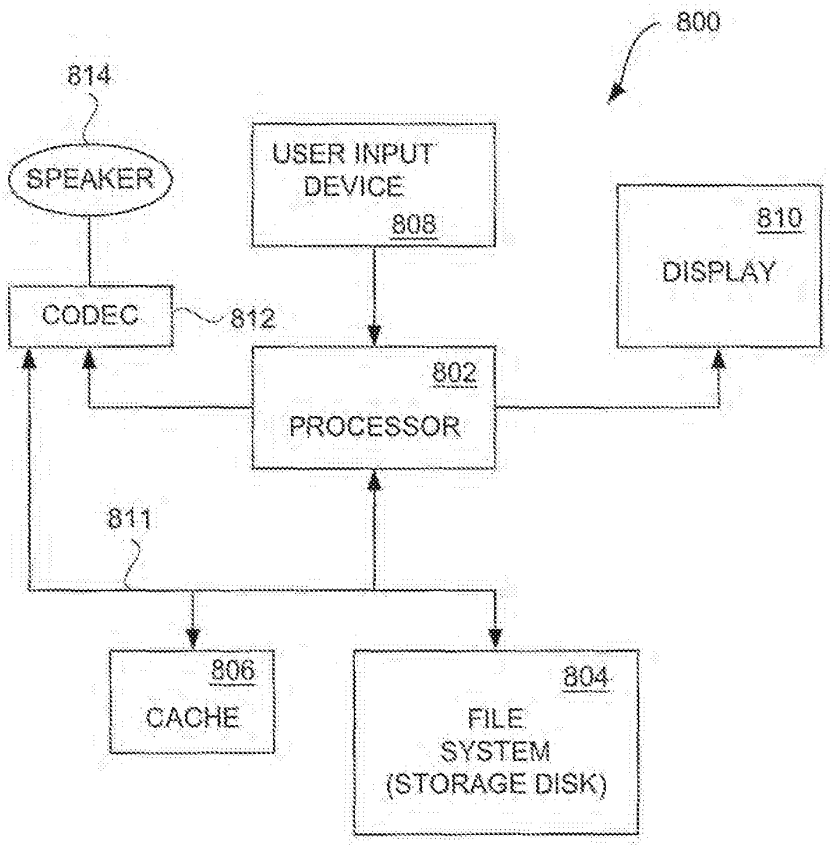

800
814
SPEAKER
USER INPUT DEVICE
808
810
DISPLAY
CODEC
812
802
PROCESSOR
811
806
CACHE
804
FILE SYSTEM (STORAGE DISK)

FIG. 8A

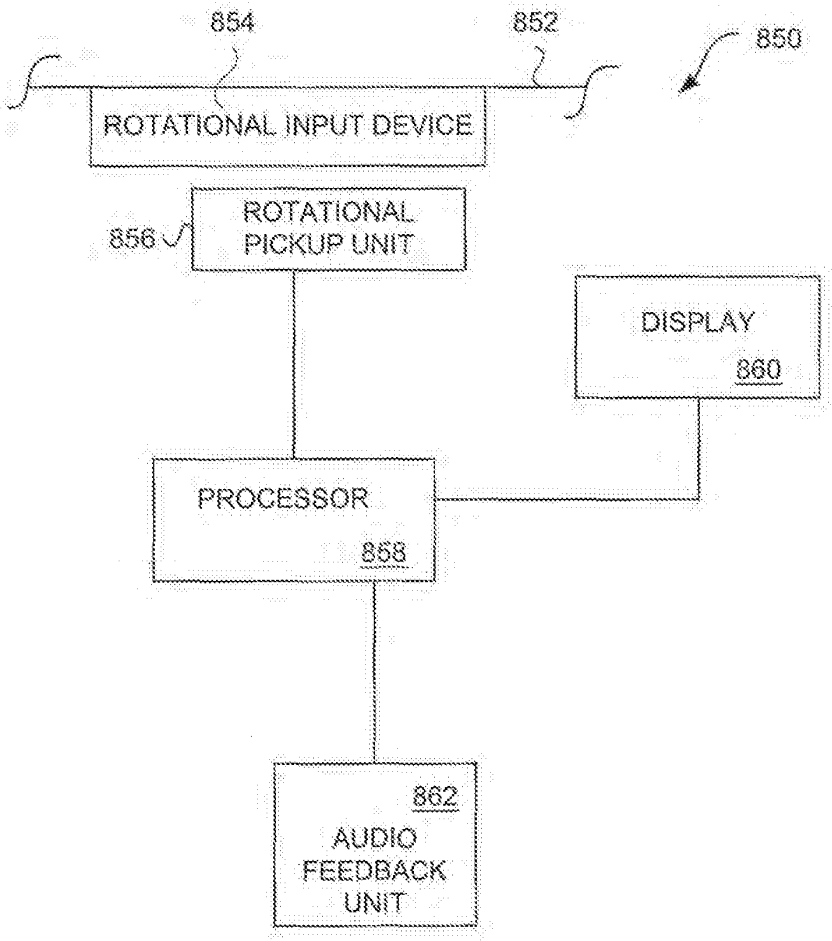

854
852
850
ROTATIONAL INPUT DEVICE
856
ROTATIONAL PICKUP UNIT
DISPLAY
860
PROCESSOR
858
862
AUDIO FEEDBACK UNIT

FIG. 8B

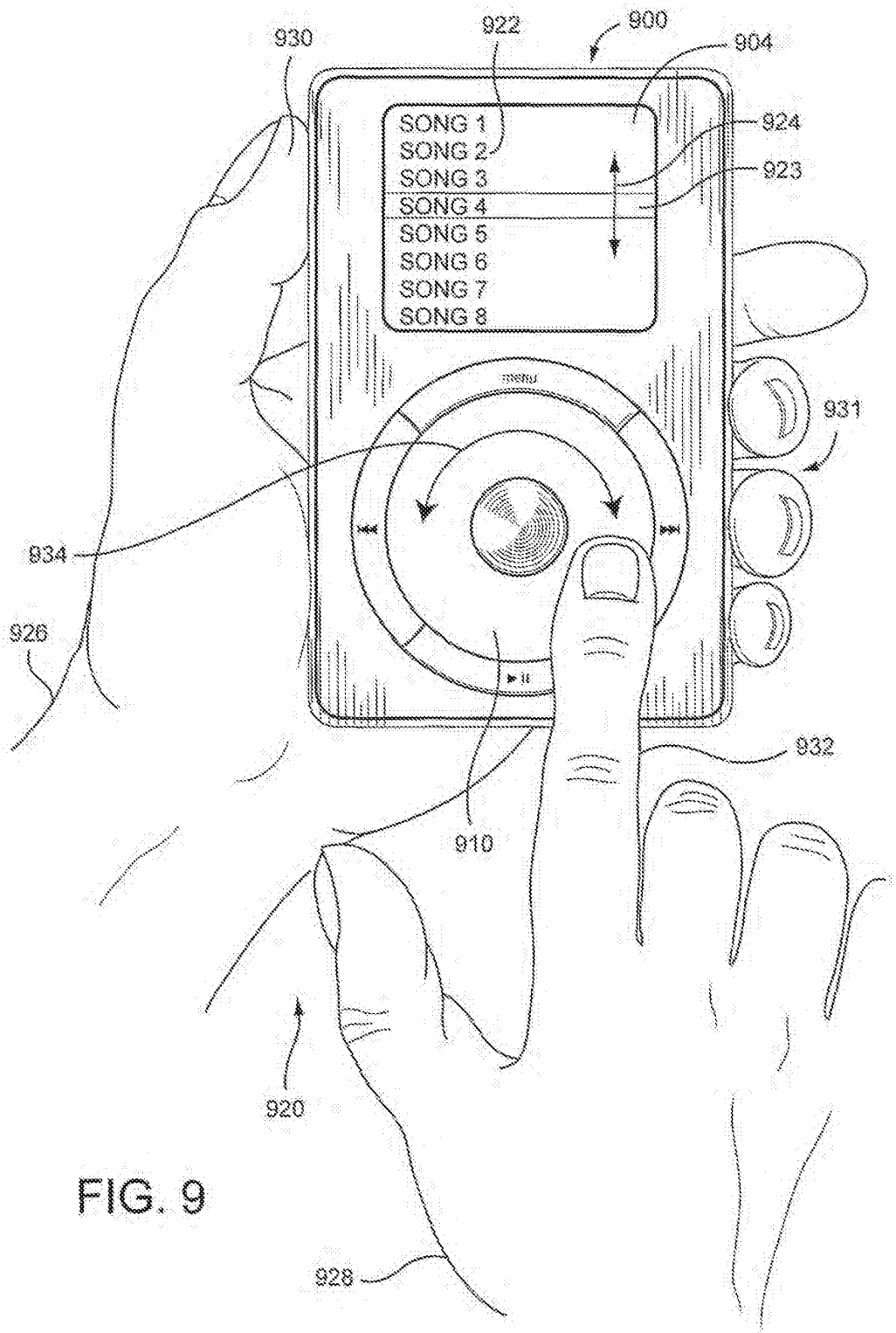

930
922
900
904
924
923
SONG 1
SONG 2
SONG 3
SONG 4
SONG 5
SONG 6
SONG 7
SONG 8
MENU
931
934
926
932
910
920
928

FIG. 9

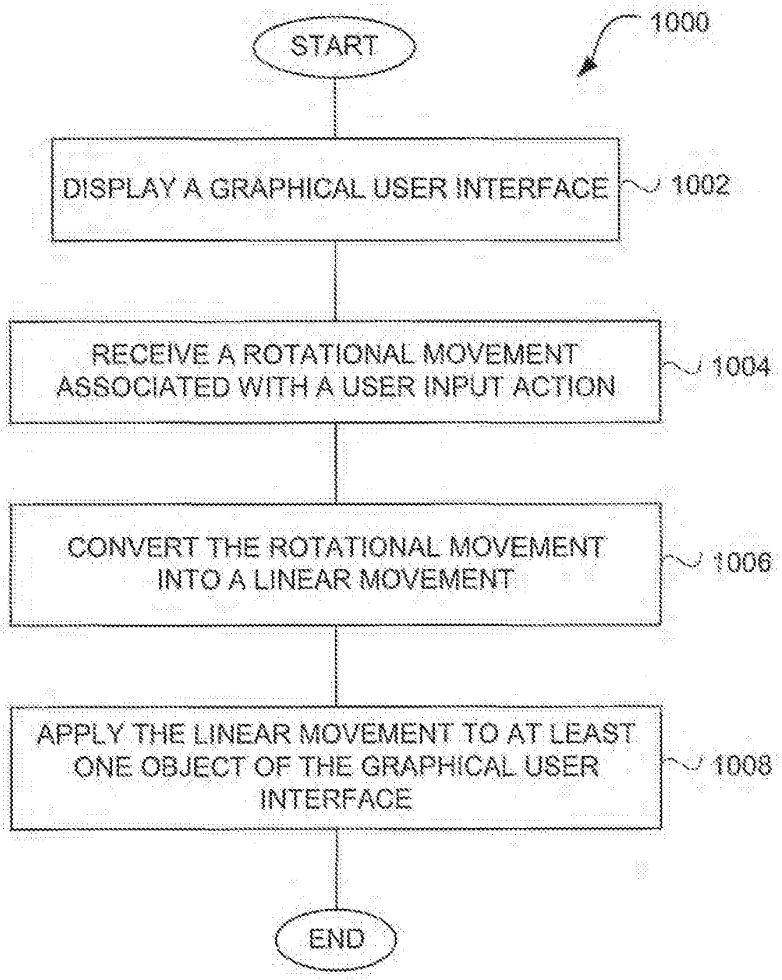

1000
START
DISPLAY A GRAPHICAL USER INTERFACE
1002
RECEIVE A ROTATIONAL MOVEMENT ASSOCIATED WITH A USER INPUT ACTION
1004
CONVERT THE ROTATIONAL MOVEMENT INTO A LINEAR MOVEMENT
1006
APPLY THE LINEAR MOVEMENT TO AT LEAST ONE OBJECT OF THE GRAPHICAL USER INTERFACE
1008
END

FIG. 10A

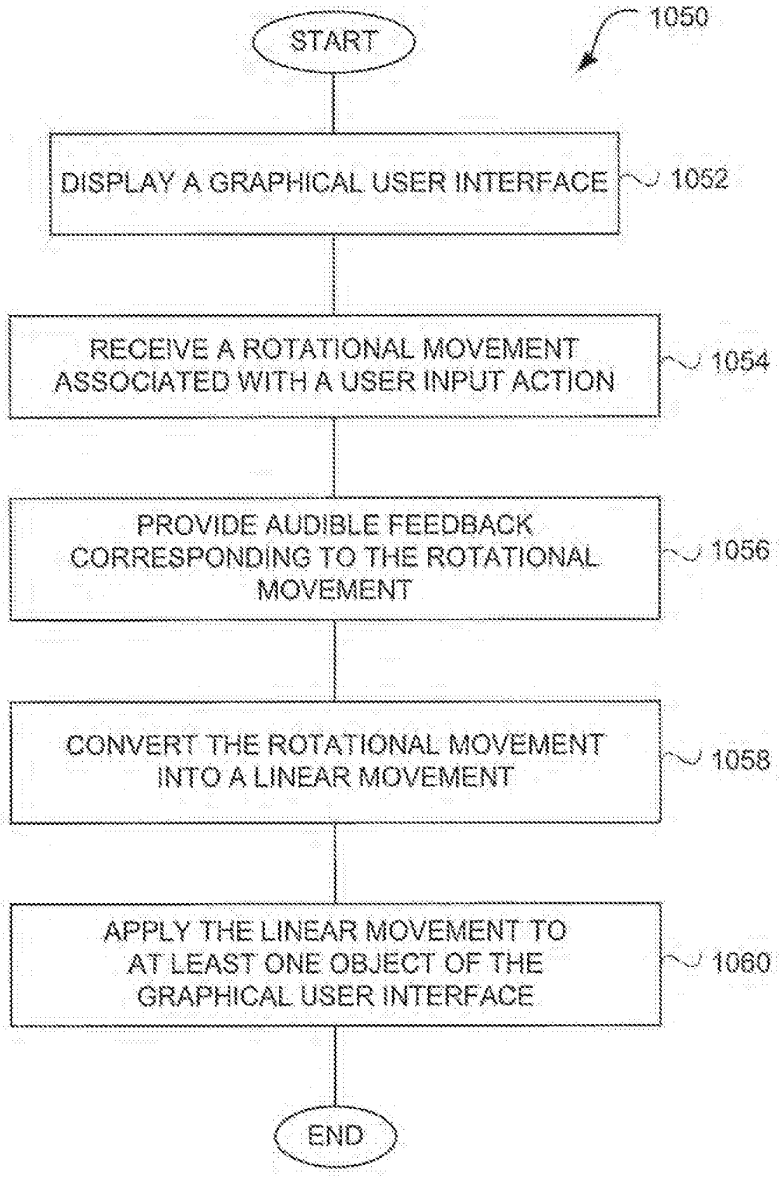

START
1050
DISPLAY A GRAPHICAL USER INTERFACE
1052
RECEIVE A ROTATIONAL MOVEMENT ASSOCIATED WITH A USER INPUT ACTION
1054
PROVIDE AUDIBLE FEEDBACK CORRESPONDING TO THE ROTATIONAL MOVEMENT
1056
CONVERT THE ROTATIONAL MOVEMENT INTO A LINEAR MOVEMENT
1058
APPLY THE LINEAR MOVEMENT TO AT LEAST ONE OBJECT OF THE GRAPHICAL USER INTERFACE
1060
END

FIG. 10B

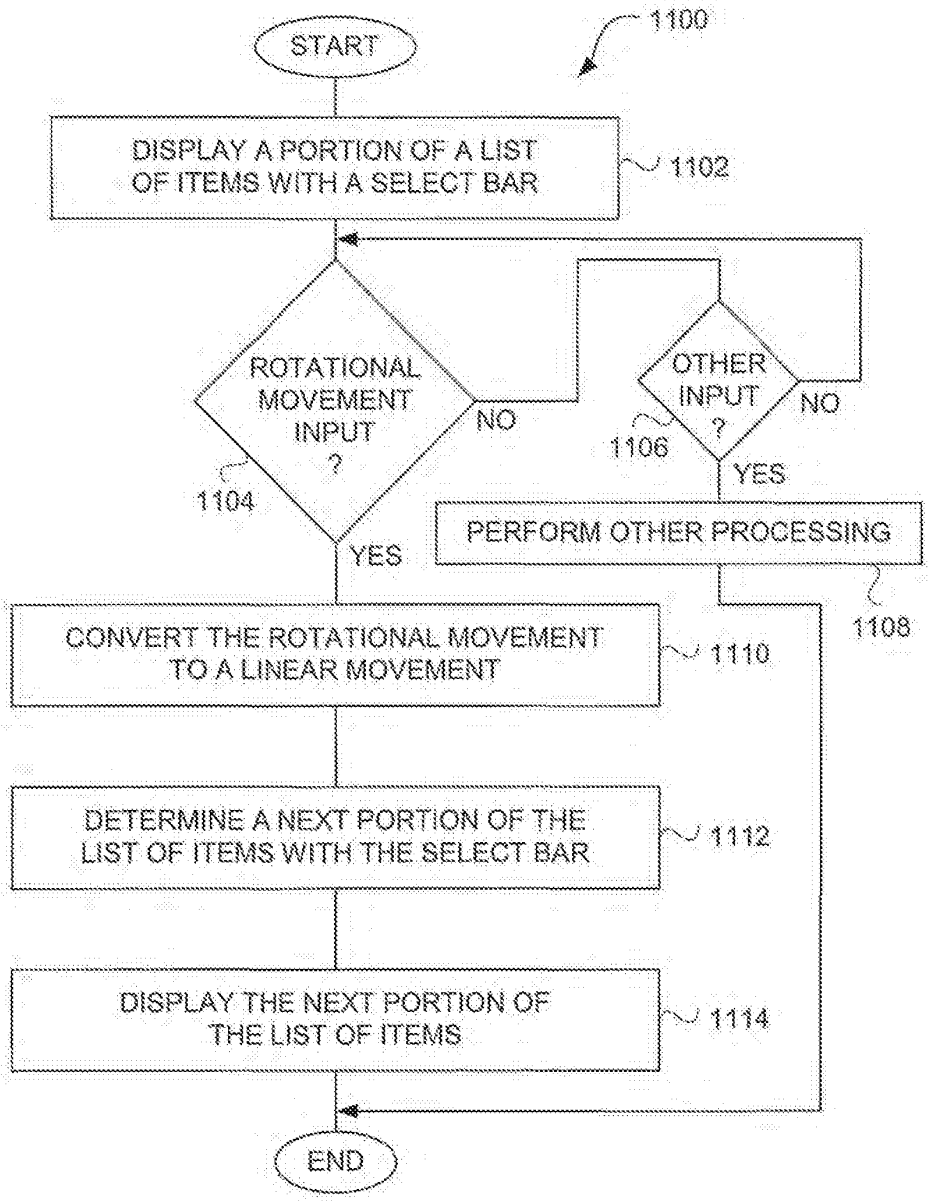

START
1100
DISPLAY A PORTION OF A LIST OF ITEMS WITH A SELECT BAR
1102
ROTATIONAL MOVEMENT INPUT ?
1104
NO
YES
OTHER INPUT ?
1106
NO
YES
PERFORM OTHER PROCESSING
1108
CONVERT THE ROTATIONAL MOVEMENT TO A LINEAR MOVEMENT
1110
DETERMINE A NEXT PORTION OF THE LIST OF ITEMS WITH THE SELECT BAR
1112
DISPLAY THE NEXT PORTION OF THE LIST OF ITEMS
1114
END

FIG. 11

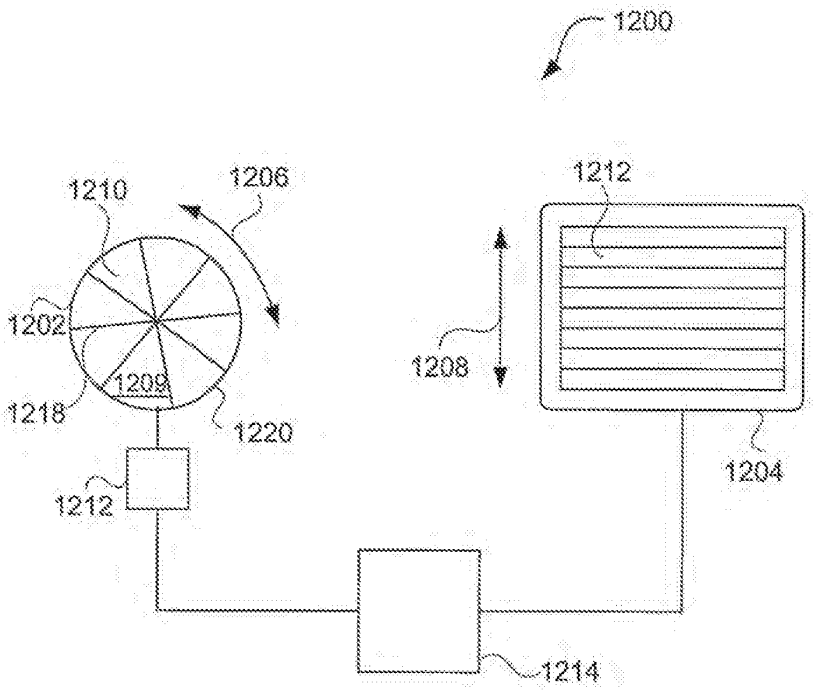


FIG. 12

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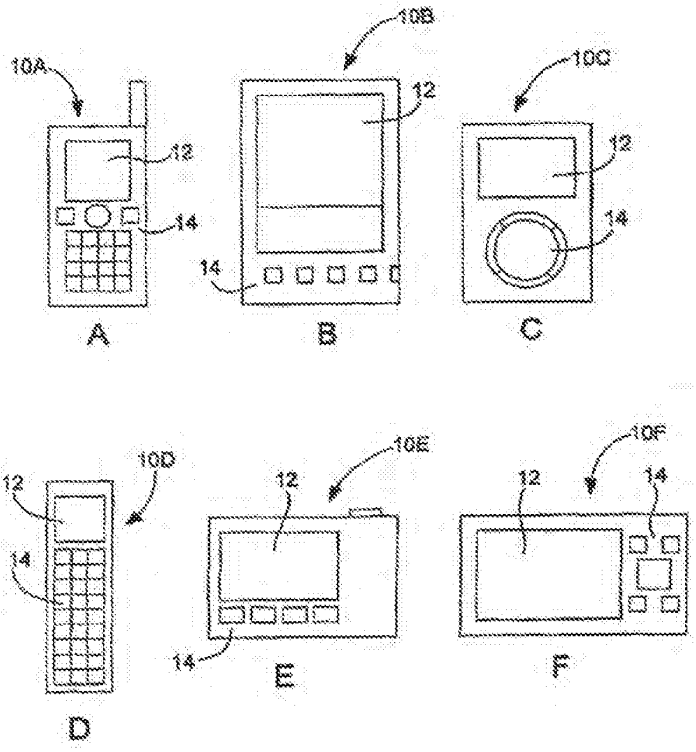
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[Continued on next page]

(54) Title: MULTI-FUNCTIONAL HAND-HELD DEVICE



(57) Abstract: Disclosed herein is a multi-functional hand-held device capable of configuring user inputs based on how the device is to be used. Preferably, the multifunctional hand-held device has at most only a few physical buttons, keys, or switches so that its display size can be substantially increased. The multifunctional hand-held device also incorporates a variety of input mechanisms, including touch sensitive screens, touch sensitive housings, display actuators, audio input, etc. The device also incorporates a user-configurable GUI for each of the multiple functions of the devices.

WO 2006/094308 A2

FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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MULTI-FUNCTIONAL HAND-HELD DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to and claims the benefit of: (1) U.S. Provisional Patent Application No.: 60/658,777, titled "Multi-Functional Hand-Held Device," filed March 4, 2005 and (2) U.S. Provisional Patent Application No.: 60/663,345, titled "Multi-Functional Hand-Held Device," filed March 16, 2005, each of which is hereby incorporated by reference.

[0002] This application is related to the following applications, which are all herein incorporated by reference: (1) U.S. Patent Application No.: 10/188,182, titled "Touch Pad for Handheld Device," filed on July 1, 2002; (2) U.S. Patent Application No.: 10/722,948, titled "Touch Pad for Handheld Device," filed on November 25, 2003; (3) U.S. Patent Application No.: 10/643,256, titled "Movable Touch Pad with Added Functionality," filed on August 18, 2003; (4) U.S. Patent Application No.: 10/654,108, titled "Ambidextrous Mouse," filed on September 2, 2003; (5) U.S. Patent Application No.: 10/840,862, titled "Multipoint Touch Screen," filed on May 6, 2004; (6) U.S. Patent Application No: 10/903,964, titled "Gestures for Touch Sensitive Input Devices," filed on July 30, 2004; (7) U.S. Patent Application No.: 11/038,590, titled "Mode-Based Graphical User Interfaces for Touch Sensitive Input Devices," filed on January 18, 2005; and (8) U.S. Patent Application No.: 11/057,050, titled "Display Actuator," filed on February 11, 2005, (9) U.S. Patent Application 11/115,539, titled "Hand-Held Electronic Device with Multiple Touch Sensing Devices," filed April 26, 2005.

BACKGROUND

[0003] There exist today many types of hand-held electronic devices, each of which utilizes some sort of user interface. The user interface typically includes an output device in the form of a display, such as a Liquid Crystal Display (LCD), and one or more input devices, which can be mechanically actuated (*e.g.*, switches, buttons, keys, dials, joysticks, joy pads) or

electrically activated (*e.g.*, touch pads or touch screens). The display is typically configured to present visual information such as text and graphics, and the input devices are typically configured perform operations such as issuing commands, making selections or moving a cursor or selector in the electronic device. Each of these well known devices has considerations such as size and shape limitations, costs, functionality, complexity, etc. that must be taken into account when designing the hand-held electronic device. In most cases, the user interface is positioned on the front face (or front surface) of the hand-held device for easy viewing of the display and easy manipulation of the input devices.

[0004] Figs. 1A–1F are diagrams of various hand-held electronic devices including for example a telephone 10A (Fig. 1A), a PDA 10B (Fig. 1B), a media player 10C (Fig. 1C), a remote control 10D (Fig. 1D), a camera 10E (Fig. 1E), and a GPS module 10F (Fig. 1F). In each of these devices 10, a display 12, which is secured inside the housing of the device 10 and which can be seen through an opening in the housing, is typically positioned in a first region of the electronic device 10. Each of these devices also include one or more input devices 14, which are typically positioned in a second region of the electronic device 10 next to the display 12.

[0005] To elaborate, the telephone 10A typically includes a display 12 such as a character or graphical display, and input devices 14 such as a number pad and in some cases a navigation pad. The PDA 10B typically includes a display 12 such as a graphical display, and input devices 14 such as a stylus based resistive touch screen and buttons. The media player 10C typically includes a display 12 such as a character or graphic display and input devices 14 such as buttons or wheels. The iPod® media player manufactured by Apple Computer, Inc. of Cupertino, California is one example of a media player that includes both a display and input devices disposed next to the display. The remote control 10D typically includes an input device 14 such as a keypad and may or may not have a character display 12. The camera 10E typically includes a display 12 such as a graphic display and input devices 14 such as buttons. The GPS module 10F typically includes a display 12 such as

graphic display and input devices 14 such as buttons, and in some cases a joy pad.

[0006] Recently, traditionally separate hand-held electronic devices have begun to be combined in limited ways. For example, the telephone 10A has been combined with the PDA 10B. One problem that has been encountered is in the way inputs are made into the device. Each of these devices has a particular set of input mechanisms for providing inputs into the device. Some of these input mechanisms are generic to all the devices (*e.g.*, power button) while others are not. The ones that are not generic are typically dedicated to a particular functionality of the device. By way of example, PDAs typically include four dedicated buttons while cell phones typically include a numeric keypad and at least two dedicated buttons.

[0007] Thus it is a challenge to design a merged device with limited input devices without adversely affecting the dedicated inputs for each device. As will be appreciated, it is preferable, not to overload the hand-held devices with a large number of input mechanisms as this tends to confuse the user and take up valuable space, *i.e.*, "real estate." In the case of hand-held devices, space is at a premium because of their small size. At some point there is not enough space on the device to house all the necessary buttons and switches, etc. This is especially true when considering that all these devices need a display that typically takes up a large amount of space on its own. To increase the number of input devices beyond some level, designers would have to decrease the size of the display. However, this will often leave a negative impression on the user because the user typically desires the largest display possible. Alternatively, to accommodate more input devices designers may opt to increase the size of the device. This, too, will often leave a negative impression on a user because it would make one-handed operations difficult, and at some point, the size of the device becomes so large that it is no longer considered a hand-held device.

[0008] Therefore what is needed in the art is an improved user interface that works for multi-functional hand-held devices.

SUMMARY

[0009] Disclosed herein is a multi-functional hand-held device capable of configuring user inputs based on how the device is to be used. Preferable, the multi-functional hand-held device has at most only a few physical buttons, keys, or switches so that its display size can be substantially increased. In other words, by eliminating physical buttons, keys, or switches from a front surface of an electronic device, additional surface area becomes available for a larger display. Ultimately this strategy would allow a substantially full screen display. As used herein, a full screen display is a display that consumes, or at least dominates, a surface (*e.g.*, front surface) of an electronic device.

[0010] Various embodiments of a multi-functional hand-held device are discussed below with reference to Figs. 2–28. However, those skilled in the art will appreciate that the detailed description given herein with respect to these figures is exemplary and not exhaustive and that many variations on these embodiments are possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

[0012] Figs. 1A–1F are diagrams of various electronic devices.

[0013] Fig. 2 is a simplified diagram of a multi-functional hand-held device.

[0014] Fig. 3 is a perspective view of a substantially full screen hand-held device with a limited number of limited buttons.

[0015] Fig. 4 is a front view of a hand-held device with at least one button.

[0016] Fig. 5 is a diagram of a GUI separated into a standard region and a control region.

[0017] Fig. 6 is a diagram of a GUI separated into a standard region and a control region.

[0018] Fig. 7 is a diagram of a GUI separated into a standard region and a control region.

[0019] Fig. 8 is a diagram of a GUI separated into a standard region and a control region.

[0020] Fig. 9 illustrates an exemplary a GUI for a PDA.

[0021] Fig. 10 illustrates an exemplary GUI for a cell phone.

[0022] Fig. 11 illustrates an exemplary GUI for a media player.

[0023] Fig. 12 illustrates an exemplary GUI for a video player.

[0024] Fig. 13 illustrates an exemplary GUI for a game player.

[0025] Fig. 14 illustrates an exemplary GUI for a camera.

[0026] Fig. 15 illustrates an exemplary GUI for a GPS.

[0027] Fig. 16 illustrates an exemplary GUI for a remote control.

[0028] Fig. 17 illustrates an exemplary GUI for a hand top.

[0029] Fig. 18 illustrates an exemplary GUI for a main menu of a multi-functional hand held device.

[0030] Fig. 19 is a side elevation view, in cross section, of a hand-held device incorporating a force sensitive display.

[0031] Fig. 20 illustrates an input device that combines touch sensing and force sensing devices to provide x, y and z components when touched.

[0032] Fig. 21 is a side elevation view of an I/O device that combines a display with touch screen and a force sensing mechanism.

[0033] Fig. 22 is a side elevation view of an input device.

[0034] Fig. 23 is a side view, in cross section, of a hand-held device that incorporates a squeeze feature.

[0035] Fig. 24 is a side view, in cross section, of a hand-held electronic device.

[0036] Fig. 25 is a block diagram of a touch sensing method.

[0037] Fig. 26 is a block diagram of touch sensing method.

[0038] Figs. 27A–E are tables representing one example of a touch vocabulary associated with a music player.

[0039] Fig. 28 is a block diagram of an exemplary multi-functional hand-held device.

DETAILED DESCRIPTION

I. MULTI-FUNCTIONALITY

[0040] Electronic device manufacturers have discovered the advantages of combining separate hand-held electronic devices to form multi-function devices. By having a single multi-function device, a user is not burdened with carrying, purchasing, and maintaining multiple devices. Further, the user is not limited in the operations that can be performed, *i.e.*, the user can perform different operations with a single device that would have otherwise required the use of a different devices.

[0041] As used herein, the term "multi-functional" is used to define a device that has the capabilities of two or more traditional devices in a single device. The multi-functional device may, for example, include two or more of the following device functionalities: PDA, cell phone, music player, video player, game player, digital camera, handtop, Internet terminal, GPS or remote control. For each new device functionality that is added to a single device, the complexity and size of the device tends to increase. Therefore, with hand-held devices, there is typically a trade-off between beeping the footprint small and complexity low while still maximizing the functionality of the device.

[0042] In some cases, combing devices may result in redundant hardware components, which allows components to be used for multiple different, device functionalities. In other cases, certain hardware components are distinct to each device and therefore additional space and connectivity must be made available. Furthermore, each device functionality typically has its own programming or application software and, therefore, the multifunction device must be designed with enough memory to accommodate all the various software components.

[0043] A personal digital assistant (PDA) is a mobile hand-held device that provides computing and information storage and retrieval capabilities for personal and/or business use. PDAs are severally capable of tracking names, addresses, phone numbers and appointments. They are also often capable of taking notes, performing calculations, paging, data messaging, and electronic mail. PDAs may also include functionality for playing simple games, music, and other media files. Examples of PDAs include the Palm Pilot and Blackberry.

[0044] Like most hand-held devices, PDAs typically include a display and various input devices. The input devices may include a stylus and touch screen that work in combination with a handwriting recognition program, keypads, mini-keyboards, navigation pads, and/or soft or fixed function buttons.

[0045] Cell phones are mobile telephones that allow a user to connect to other telephones using a cellular network. Cell phones typically include a transceiver for transmitting and receiving telephone calls, controls such as a navigation pad for traversing through a display, a keypad for making numeric entries (and in some cases alphabetic entries), and soft or fixed function buttons. For example, in many cell phones one fixed function button is used for starting a call and another fixed function button is used for ending a call.

[0046] Media players come in a variety of forms. Music players are generally configured to store, process and output music. Music players can be based on the MP3 or AAC format, which is a compression system for music. Music Players typically include a microprocessor, memory, display, audio jack, data port and playback controls. The playback controls typically include features such as menu, play/pause, next, previous, volume up, and volume down. Video players are similar to music players in most respects. In some cases, they may include a data storage device for receiving a removable storage medium such as a DVD. The iPod® media player manufactured by Apple Computer, Inc. of Cupertino, California is one example of a media player.

[0047] Handtops are general purpose computers similar to laptops, but in a smaller form factor. Handtops typically include a display and a full keyboard.

[0048] Fig. 2 is a simplified diagram of a multi-functional hand-held device 100. The multi-functional hand-held device 100 integrates at least two devices 102 into a single device. Each device 102 includes both hardware and software components 104 and 106, which are integrated into multi-functional hand-held device 100. It should be pointed out that the multi-functional hand-held device 100 is not limited to only two devices, and may in fact integrate any number of devices.

[0049] Multi-functional device 100 also includes switch 110, which that allows multi-functional device 100 to be switched from one device operating mode to another device operating mode. For example, switch 110 may allow a user to cycle through cell phone, media player, and PDA modes of operation. Once a particular operating mode is selected, the multi-functional device 100 operates as the selected device. For example, the programming related to the selected device is activated for use by the multi-functional hand-held device. The programming may include reconfiguring the UI based on the selected device so that the inputs made by the user correlate to the device in use. For example, the functions of any physical buttons, switches or dials as well as soft buttons, switches or dials can be reconfigured to correspond to the selected device.

[0050] However, the operating modes of multi-functional hand-held device 100 need not completely independent. In many cases, it will be desirable to allow the multiple functionalities to interact with each other. For Example, a user may look up a telephone number of a contact in the PDA and pass this number to the phone to be dialed.

II. FORM FACTOR

[0051] The form factor of a hand-held device is generally a device that can easily be held in one hand. A typical hand-held device includes a small display in an upper portion of the front surface of the device and input controls in a lower portion of the front surface of the device. The device may additionally include controls and ports on the top, bottom, and side surfaces. Prior art hand-held devices have typically had small displays which causes some dissatisfaction for users of these devices. It is generally preferred to have larger displays so that more information can be displayed or the information being displayed can be more easily viewable (*e.g.*, larger text). In the case of video players and game players in particular, larger displays are much preferred over smaller ones.

[0052] However, the use of large displays has been limited in the past because the required input controls often take up substantial portions of the available space. Furthermore, as device functionality converges, the number of controls on the device typically increases as each device includes its own dedicated controls. Therefore devices must be made larger or the displays must be smaller to accommodate all the new controls. Both of these outcomes are unsatisfactory. Larger devices are bulky and hard to use, and smaller screens are difficult to utilize for both relaying information and reading information from the screen.

A. ONE-HANDED VS. TWO-HANDED OPERATION

[0053] A hand-held electronic device may be directed at one-handed operation or two-handed operation. In one-handed operation, a single hand is used to both support the device as well as to perform operations with the user interface during use. Cellular phones and media players are examples of hand-held devices are generally intended to can be operated solely with one hand. In the case of a cell phone, for example, a user may grasp the phone in one hand between the fingers and the palm and use the thumb to make entries using keys, buttons or a # joy pad.

[0054] In two-handed operation, one hand is used to support the device while the other hand performs operations with a user interface during use or, alternatively, both hands support the device as well as perform operations during use. PDA's and game players are examples of hand-held device that are typically operated with two hands. In the case of a PDA, for example, the user may grasp the device with one hand and make entries using the other hand, for example, using a stylus. In the case of a game player, the user typically grasps the device in both hands and make entries using either or both hands while holding the device.

B. FOOTPRINT/SIZE

[0055] Hand-held devices may have a variety different footprints or sizes. The footprint is typically associated with how the device is going to be used. Devices such as PDAs are typically used with both hands and thus they tend to be larger. Alternatively, cell phone handsets are typically used with only one hand, and thus they tend to be smaller. When integrating multiple devices, it is important task to determine the appropriate footprint of the device. For example, some believe that PDAs are too large for phone use while cell phones are too small for PDA use. Designers generally must consider the primary use of the device and gear the footprint towards that use. Although there are different footprints, there are typically minimum and maximum footprints. If the footprint is too large or too small, the device may be difficult to use.

[0056] Because of their size, the smaller devices are typically placed in a pocket while the larger devices are not. A media player is one example of a hand-held device that is sized for placement into a pocket of the user. By being pocket-sized, the user does not have to directly carry the device and therefore the device can be taken almost anywhere the user travels (*e.g.*, the user is not limited by carrying a large, bulky and often heavy device, as in a laptop or notebook computer).

[0057] Generally it is preferred, although not necessary, that hand-held devices of the type disclosed herein have dimensions of about 5 in x 3 in x 1 in and perhaps about 4.1 in x 2.4 in x 0.75 in.

C. FULL SCREEN DISPLAY

[0058] Because the footprint of a multifunctional hand-held device is substantially fixed by the intended primary use of the device, it becomes important for designers to determine an appropriate layout for the UI. For example, some devices may work better with a limited number of buttons and a large display while others may work better with a large number of buttons or a complete keyboard and a small display.

[0059] A preferred multi-functional hand-held device may be configured with a full screen display or a near full screen display. A full screen display consumes substantially the entire front surface of the device. The display may extend edge to edge or may fit within a small bezel of the housing at the edge of the device. The full screen display may consumes 90% or more of a front surface of a housing for a hand-held electronic device.

[0060] The full screen display may have a variety of different configurations depending on the overall footprint of the device. If the device is wide, the full screen display may have a traditional aspect ratio of about 4:3. If the device is elongated, the full screen display may have an aspect ratio that is more panoramic such as 16:9.

D. LIMITED NUMBER OF MECHANICAL ACTUATORS

[0061] To accommodate a full screen display, the multi-functional hand-held device is preferably configured with a limited number of physical buttons. Because a limited number of physical buttons are provided, the hand-held device preferably uses a touch screen as the primary input device. Touch screens are transparent touch sensing devices that are positioned over displays. They typically work in conjunction with a GUI presented on the display. For example, the GUI may present an on-screen button, and the touch screen may detect when a user presses the on-screen button (*e.g.*,

places their finger or stylus over the on-screen button). Touch screens and GUI's are described in greater detail below.

[0062] The hand-held device may be constructed with only cross-functional physical buttons, *i.e.*, there are no buttons dedicated to individual devices. These type of buttons may include power buttons and hold switches. In another embodiment, the hand-held device may not include any physical buttons at all. In some embodiments, the physical buttons are limited to only the sides and back surface of the hand-held device. In other embodiments, the physical buttons of the hand-held device are limited to the upper and lower portion of the sides so that there are no buttons in the regions of the sides where a user would physically support the device (*i.e.*, holding region). In still other embodiments, the physical buttons may be located on the front surface, but only in the bezel region surrounding the display. In some embodiments, the buttons may be located on only the top and bottom surfaces of the device.

[0063] Fig. 3 is a perspective view of a substantially full screen multi-functional hand-held device 120 with a limited number of buttons. There are no physical buttons on the front and side surfaces 124 and 126. The front surface is used entirely for the display 122. Further, because the sides 126 are used for grasping the device 120 it may be preferred to leave the sides free from buttons to prevent accidental actions in the event a user inadvertently presses a button while supporting the device. Although the top surface 128 and bottom surface 13 O would not typically be used to hold the device, these surfaces are not ideal locations for buttons that are often actuated because it would be awkward to reach these buttons when operating the device with one hand.

[0064] The top surface 128 may be reserved for buttons that have limited action and generic functions that are cross-functional, for example, power and hold switches. The top and bottom surfaces 128 and 130 are also well suited for placement of I/O and communication ports. The top surface 128 may, for example, include a headset/microphone jack and an antenna, and the bottom surface 130 may include power and data ports.

[0065] In some cases, it may be desirable to place buttons in the upper or lower regions of the side surfaces 126 out of the way of the grasping hand. This may be particularly well suited for elongated devices that are larger than the width of the grasping hand. As shown in Fig. 4, the hand-held device 120 includes a button 140 in the upper region on the side surface 126 of the hand-held device 120. Because the button 140 is in the upper region, it tends to be out of the way of the grasping hand and therefore accidental activation is substantially eliminated. The upper button may be configured to switch the functionality of the multi-functional device *i.e.*, button 140 may be switch 110 of Fig.2. For example, by pressing the button 140, a new device functionality is activated, and the current device functionality is deactivated. Although the term button is used, it should be appreciated that the button 140 may correspond to a dial, wheel, switch and/or the like.

[0066] Generally it would be preferred, although not required, to limit the number of physical buttons to eight or fewer, and perhaps five or fewer.

III. ADAPTABLITY

[0067] To limit the number of physical controls on the device (thereby maximizing the display area), the multi-functional hand-held device is preferable adaptable, *i.e.*, the device is capable of changing its UI based on how the device is to be used. For example, if a cell phone functionality of the multi-functional device is to be used, the UI changes to accommodate the cell phone. Alternatively, if the PDA aspect of the multi-functional device is to be used, the UI changes to accommodate the PDA, etc. In essence, the multi-functional device is capable of reconfiguring its user interface based on the state or mode of the device.

[0068] Adaptability may be accomplished by reassigning the functions of the limited number of physical buttons for each device functionality. For example, a button may perform one function when a first device is activated and another when another device is activated. While this may work, it suffers from physical limitations (*i.e.*, the number of buttons) and can be confusing to the user (who must keep track of different button meanings).

[0069] Alternatively adaptability may be accomplished by virtually incorporating the physical inputs for each functionality into the GUI in conjunction with a touch screen. This allows the GUI to adapt to whatever device is selected, and the touch screen can receive inputs corresponding to the GUI. With a GUI for each functionality, the UI for the hand-held device adapts such that the multi-function device, in effect, becomes a particular device. For example, if the cell phone functionality is selected, the GUI presents a set of virtual or soft controls that look similar to the physical controls typically used on a cell phone, such as a keypad, function buttons and possibly a navigation pad, for example.

[0070] The entire display may be used to present this information, or only a portion of the display may be used for the GUI controls. In the later case, referring to Figs. 5–8, the GUI 150 may be separated into a standard region 152 and a control region 154. The standard region 152 represents what would normally be displayed on the display 122 when using a particular device. That is, the standard GUI screens associated with the selected device are displayed in the standard region. For example, in the case of the PDA, a main menu (window with a set of icons), calendar, address book or date book may be displayed in the standard region 152. The control region 154, on the other hand, virtually represents the physical controls that would normally be physically placed on a particular device. That is, the virtual controls that mimic the physical controls are displayed in the control region 154. For example, in the case of the PDA, the control region 154 may include virtual representations of a hand writing recognition area, a navigation pad and the standard function buttons.

[0071] The standard and control regions 152 and 154 can be positioned at any position on the display 122 (top, bottom, sides, center, etc.). For example, as shown in Fig. 5, they may be positioned vertically relative to one another (one on top of the other) or as shown in Fig. 6, they may be positioned horizontally relative to one another (side by side). These configurations can be used in either portrait or landscape modes. By way of example, in cases where the device is operated in landscape mode, the

standard region 152 may be placed on one side and the control region may be placed on the opposite side. Landscape orientation may, for example, facilitate one handed operation. In some cases, the side on which the controls are displayed is based on the handedness of the user. For example, the controls may be place on the right side for right-handed users, and the controls may be placed on the left side for left-handed users. Alternatively, the controls may be placed on both sides as shown in Fig. 7. This arrangement is particularly well suited for game playing. Furthermore, the amount of area dedicated to each portion may be widely varied. For example, the screen may be divided equally and in other cases one or the other portion constitutes a greater amount of the display. In some cases, the standard region 154 is maximized to increase the normal viewing area of the display.

[0072] When a particular functionality is selected for use, the hand-held device loads the software for the selected functionality and configures the GUI 150 including the standard region 152 and the control region 154. The controls in the control region 154 can therefore be used to control whatever is being shown in the standard region 152. In some cases, the control region 154 may even change in accordance with the needs of each displayed window for the particular device.

[0073] Alternatively, as shown in Fig. 8, virtual controls 160 may be overlaid on top of the standard region 152 so that the standard region 152 can fully utilize the entire display 122. In fact, the virtual controls 160 may appear and disappear as needed. For example, the user may touch the screen and this may drive the device to display the controls over a portion of the display including whatever is already displayed. Examples of virtual controls that operate in this manner can be found in U.S. Patent Application No.: 11/038,590, titled "Mode-Based Graphical User Interfaces for Touch Sensitive Input Devices," filed on January 18, 2005.

A. GUI BASED ON FUNCTIONALITY

[0074] Figs. 9–17 illustrate various examples of GUIs for different states or modes of the multi-functional device.

[0075] Fig. 9 is a diagram of a GUI 170 that is used in a PDA mode. As shown, the GUI is divided into a standard region 152 and a control region 154. Located inside the control region 154 are a virtual handwriting pad 172, four virtual buttons 174 and a virtual navigation pad 176.

[0076] Fig. 10 is a diagram of a GUI 180 that is used in a cell phone mode. As shown, the GUI 180 is divided into a standard region 152 and a control region 154. Located inside the control region 154 are a virtual keypad 182, a virtual navigation pad 184 and two virtual buttons 186.

[0077] Fig. 11 is a diagram of a GUI 190 that is used in a music player mode. As shown, the GUI 190 is divided into a standard region 152 and a control region 154. Located inside the control region 154 are a virtual scroll wheel 192 and five virtual buttons 194. Additional details on a virtual scroll wheel are provided in U.S. Patent Application No.: 11/038,590, titled "Mode-Based Graphical User Interfaces for Touch Sensitive Input Devices," filed on January 18, 2005.

[0078] Fig. 12 is a diagram of a GUI 200 that is used in a video player mode. As shown, the GUI 200 is divided into a standard region 152 and a control region 154. Located inside the control region 154 are a plurality of virtual buttons 202. Alternatively, the controls may appears and disappears as needed since the video player is primarily used in conjunction with a full screen viewing mode.

[0079] Fig. 13 is a diagram of a GUI 210 that is used in a game player mode. As shown, the GUI 210 is divided into a standard region 152 and two control regions 154A and 154B on the sides of the standard region 152. The left side control region 154A includes a navigation or directional pad 212, and the right side control region includes four virtual buttons 214 (or vice versa depending on the users particular needs, left or right handed).

[0080] Fig. 14 is a diagram of a GUI 220 that is used in a camera mode. As shown, the GUI 220 is divided into a standard region 152 and a control region 154. The standard region 152 may represent the view finder.

Located inside the control region 154 are various buttons 222 including for example picture click, zoom, flash, etc. A navigation pad 224 may also be included so that the pictures can be scrolled through or for menu navigation.

[0081] Fig. 15 is a diagram of a GUI 230 that is used in a GPS receiver mode. As shown, the GUI 230 is divided into a standard region 152 and a control region 154. Located inside the control region 154 are various buttons 222 including for example zoom, pan, etc. A navigation pad 224 may also be included.

[0082] Fig. 16 is a diagram of a GUI 240 that is used in a hand top mode. As shown, the GUI 240 is divided into a standard region 152 and a control region 154. Located inside the control region 154 is a virtual keyboard 242.

[0083] Fig. 17 is a diagram of a GUI 250 that is used in a remote control mode. As shown, the GUI 250 is divided into a standard region 152 and a control region 154. Located inside the control region 154 are various keys and buttons 252 associated with controlling a remote device such as a TV, DVD player, A/V amplifier, VHS, CD player, etc.

B. SWITCHING BETWEEN DEVICES (GUI)

[0084] Before a particular device functionality can be used, it typically must be selected for use. The selection can come in a variety of forms. For example, the selection may be made via a main menu that includes soft buttons or icons that, when selected, activate the device functionality associated with the soft button. During activation, the GUI for that particular device is brought into view on the display (see Figs. 9–17) and the software associated with the device is installed, loaded or activated. From that point on, the multi-functional device operates like the selected device.

[0085] Fig. 18 illustrated an exemplary main menu GUI 260 of a multi-functional device. As shown, the GUI 260 includes icons/buttons 262 for launching each of the various device functionalities. In this particular example, the main menu page 260 includes a PDA button 262A, a cell phone button 262B, a music player button 262C, a game player button 262D, a

video player button 262E, a GPS button 262F, a remote control button 262G, a camera button 262H and a handtop button 262I. The various buttons 262 are virtual buttons. When a button is pressed, the main page for the selected functionally (*e.g.*, as shown in Figs. 9–17) is brought into view on the display. To select another device, the user simply selects a soft home button 264 located in the GUI of each device to return to the main menu page 260, and thereafter selects the desired functionality in the main menu page 260.

[0086] The selection of alternative functionalities may also be accomplished by flipping (or scrolling) through the various GUIs until the desired GUI is found. For example, the different GUIs may be incrementally brought into view page after page (or frame after frame) when a next (flip) command signal is generated (e.g., slide show effect). The transition between pages may be widely varied. The transition may be from side to side, top to bottom or center to center. The transition may also include fading in and out, popping in and out, or enlarging and reducing. The command signal may be generated by a physical or virtual button or wheel. Using a button, each press may cause a new page to be displayed. Using a wheel, a predetermined amount of rotation may cause a new page to be displayed.

[0087] The command signal may also be generated in a variety of other ways. For example, the command signal may also be generated by gestures initiated on the touch screen. For example, sliding a finger (or stylus) across the display may cause a new page to be displayed. If slid to the right, the next page may be displayed. If slid to the left, the previous page may be displayed. The command signal may also be generated by 3D device gestures created when the entire hand-held device is moved spatially. By way of example, shaking the device may cause a new page to be displayed.

[0088] The command signal may also be generated by forces that are applied to the device. By way of example, squeezing the device may cause a new page to be displayed. The command signal may also be generated by sensing the orientation of the device either relative to the ground, as sensed by accelerometers, or relative to a compass direction indicated by an internal

compass. For example, if the device is at 0 degrees, a first page is displayed, at 90 degrees a second page is displayed, at 180 degrees a third page is displayed and at 270 degrees a fourth page is displayed.

[0089] The command signal may also be generated by monitoring a user's voice (*i.e.*, voice recognition). If the user calls out "PHONE," the page associated with the phone is displayed, if the user calls out "PDA," the page associated with the PDA is displayed.

[0090] The command signal may also be generated by monitoring incoming signals from other systems (whether transmitted wirelessly or via a cable). For example, if a call is received, the device may automatically configure the system as a phone. Alternatively, it may only present a control panel for taking or passing on the call.

[0091] As an alternative to integrating functionalities, the device may be configured to keep the various modes separate. That is, the device does not merge the functionality together (integrated layers and GUIs), but instead keeps them distinct from one another. In some cases, by keeping different functionalities distinct, user confusion may be reduced.

C. OPERATING AT LEAST TWO FUNCTIONALITIES SIMULTANEOUSLY

[0092] Preferably, the user may be able to activate two or more device functionalities simultaneously. In such a case, the software for the multiple functionalities is activated simultaneously and the display operates in a split screen mode where the screen is parsed into different sections, each section including a particular device GUI. Generally this would require the GUI for each functionality to fit on the screen. The multi-function mode may be selected in a variety of ways. In one implementation, when the user simultaneously touches two or more device icons, the device activates the multiple device functionalities and brings the appropriate GUIs into view on the screen.

D. CONFIGURABLE GUI (USER PREFERENCES)

[0093] The GUI control panels for each device functionality may be configurable by the user. For example, the user may design or customize his

own UI for each device, and assign functions to the various elements of the UI. The functions may include initiating commands, selecting an item, opening a file or document, launching a program, executing instructions, viewing a menu on the display screen, etc. The parameters configurable by the user may include selecting the number and type of GUI elements (buttons) as well as the location of the GUI elements on the page. In some cases, the system may include a design palette that allows a user to review and/or customize the UI layout, *i.e.*, the user may quickly and conveniently review preconfigured or default layout and make changes thereto. Once changed, the modified layout will be automatically saved and thereby employed to handle future events.

IV. INPUT DEVICES

[0094] There are a number of problems with current input devices for hand-held computers. For example, there is no realistic way to fit all the dedicated physical buttons that are needed for each device because more and more buttons must be fit into a small space. A related problem arises in that as more physical buttons are incorporated into the device, the buttons must get closer together thereby challenging the dexterity of the user. Furthermore, because physical buttons stick out they are often accidentally activated during normal use or while the device is transported *e.g.*, in a user's pocket. Finally, large numbers of small physical buttons can be confusing to the user as well as aesthetically unpleasing.

[0095] To overcome these and other problems a variety of alternative inputs arrangements are proposed (in addition to or in place of physical buttons, switches, etc.). The basic idea is to reduce the number of physical and mechanical input mechanisms (and therefore the amount of dedicated space needed on the surface of the device) and/or eliminate the physical and mechanical input mechanisms altogether. By reducing or eliminating the physical input devices, the display of the electronic device can be maximized, or alternatively the size of the electronic device can be minimized. Furthermore, such a device is more aesthetically pleasing. In some cases, the

hand-held device can be configured so that it appears to only have a display and no dedicated physical input devices.

[0096] The alternative input means may also be hidden from view such that they are not visible to the user. As a result, the hand-held electronic device may appear to only have a display with no visible buttons, switches, etc. Such a device is more aesthetically pleasing (*e.g.*, may comprise smooth surfaces with no breaks gaps or lines), and, in many cases, can be made smaller without sacrificing screen size and input functionality.

A. TOUCH SCREEN

[0097] One particularly suitable input arrangement is a touch screen. A touch screen in conjunction with GUI may be configured as the primary input arrangement for a hand-held device. A touch screen is basically a transparent input panel positioned in front of the display. A touch screen generates input signals when an object such as a finger or stylus touches or is moved across the surface of the touch screen. In most cases, touch screens allow a user to make selections and initiate movements in a GUI by simply touching the display screen via a finger. For example, a user may make a selection by pointing directly to a graphical object displayed on the display screen. Corresponding to an on-screen button for performing specific actions in the hand-held electronic device. In general, the touch screen recognizes the touch and position of the touch on the display and a controller of the hand-held electronic device interprets the touch and thereafter performs an action based on the touch event. There are several types of touch screen technologies including resistive, capacitive, infrared and surface acoustic wave.

[0098] A preferred touch screen for a multi-functional hand-held computer is a multipoint capacitive touch screen. Such a touch screen comprises several independent and spatially distinct sensing points, nodes, or regions that are positioned throughout the touch screen. The sensing points are dispersed about the touch screen with each sensing point representing a different position on the surface of the touch screen. The sensing points may

be positioned in a grid or a pixel array where each sensing point is capable of generating a signal. A signal is produced each time an object is positioned over a sensing point. When an object is placed over multiple sensing points or when the object is moved between or over multiple sensing point, multiple signals can be generated. The sensing points generally map the touch screen plane into a coordinate system such as a Cartesian coordinate system or polar coordinate system. One example of such a touch screen is disclosed in U.S. Patent Application No.: 10/840,862, titled "Multipoint Touch Screen" filed on May 6, 2004.

B. TOUCH SENSITIVE HOUSING

[0099] A hand-held electronic device may also incorporate one or more include a touch sensitive surfaces of the device housing itself that provide either a larger surface for tracking touch inputs or smaller dedicated areas such as touch buttons for performing dedicated functions. Such surfaces may be located on any surface of the housing, any side of the housing, any portion of any side of the housing or at dedicated locations on the surface of the housing. For example, the touch regions may be located on the sides or back surface of the housing, and may even be located at the bezel located at the front surface of the housing. In all of these cases, a large portion of the front surface of the housing is saved for the display so that the viewing area of the hand-held electronic device can be maximized. The touch sensitive surfaces of the housing may take the form of one or more touch panels that are positioned within the housing. The touch sensitive surface may be alternatively or additionally be provided directly by the housing. That is, the touch sensing components may be integrated or incorporated into or disposed underneath the housing such that the housing itself is the touch sensing device (rather than using a separate touch panel). Similarly to a touch screen, a touch sensitive housing recognizes the touch and position of a touch on the surface and a controller of the hand-held electronic device interprets the touch and thereafter performs an action based on the touch event.

Touch surfaces are constructed in basically the same manner as a touch screen, except the surfaces need not be substantially transparent.

[0100] By way of example, the touch sensitive housing may generally correspond to the touch sensitive housing described in greater detail U. S. Patent Application 11/115,539, titled "Hand-Held Electronic Device with Multiple Touch Sensing Devices," filed April 26, 2005.

C. DISPLAY ACTUATOR

[0101] A hand-held multi-functional electronic device may also include a display actuator, which is an input device that mechanically uses the display of the hand-held device to provide inputs into the device (rather than electrically as with a touch screen). The display actuator may be used separately or in combination with the touch screen. The display actuator may include a movable display that causes one or more input signals to be generated when moved. The input signals then can be used to initiate commands, make selections, or control motion in a display.

[0102] The movable display may be configured to translate, slide, pivot, and/or rotate relative to the frame. The display is typically movable relative to a frame or housing that movably supports the display in its various positions. In some cases, the display is movably coupled to the frame, and in other cases the frame movably restrains a floating display.

[0103] The input signals may be generated by movement indicator(s) that monitor the movements of the display and produces signals indicative of such movements. The detection mechanism may, for example, one or more switches, sensors, encoders, and/or the like. Any suitable mechanical, electrical and/or optical switch, sensor or encoder may be used. For example, tact switches, force sensitive resistors, pressure sensors, proximity sensors, infrared sensors, mechanical or optical encoders and/or the like may be used. The movement indicators may be placed underneath the display or at the sides of the display as appropriate. Alternatively or additionally, these movement indicators may be attached to the display or some component of the display.

[0104] An exemplary display actuator is disclosed in U.S. Patent Application No. 11/057,050, titled "Display Actuator," filed on February 11, 2005.

D. PRESSURE OR FORCE SENSING DEVICES

[0105] The multi-functional hand-held electronic device described above may further include force or pressure sensing devices such as a force sensing display or housing.

1. Force Sensitive Display

[0106] A force sensitive display causes one or more input signals to be generated when pressure is exerted on the display screen of the device. The input signals can be used to initiate commands, make selections, or control motion in a display. Such displays generally provide a slight amount of flex (unnoticeable to the user) so, that any forces exerted thereon can be measured by a force detection arrangement generally provided underneath the display. The force detection arrangement monitors the forces exerted on the display and produces signals indicative thereof. The force detection arrangement may include one or more force sensors such as force sensitive resistors, force sensitive capacitors, load cells, pressure plates, piezoelectric transducers, strain gauges, etc. The force sensors may be attached to the back of the display or to a structural platform located within the housing of the device. When a force is applied to the display, it is transmitted through the display to the force sensor located underneath the display.

[0107] Fig. 19 is a side elevation view, in cross section, of a hand-held device 300 incorporating a force sensitive display 302. The force sensitive display 302 includes a display 308 and one or more force sensors 310 disposed underneath the display 308 (between the display and a structural platform 306). In most cases, the force sensitive display 302 includes a plurality of sensors 310 that are laid out in an array. For example, the sensors 310 may be positioned side by side in rows and columns. The force sensors 310 measure the amount of force being applied to the display and when a desired force threshold is reached a control signal is generated. In

some cases, an elastomer 312 is placed between the display and the structural platform to help transmit the force being exerted on the surface of the display to the force sensors disposed below the display.

[0108] Force sensing may be provided in conjunction with a touch screen to differentiate between light and hard touches. The determination of whether a touch is a light touch or a hard touch may be made by monitoring the force with the force sensors and comparing the force to a predetermined threshold. When the force threshold is not exceeded, the touch is considered a light touch. When the force threshold is exceeded, the touch is considered a hard touch. Each type of touch may be used to control different aspects of the device. Light touches may be associated with passive events such as navigation (*e.g.*, cursor control scrolling, panning, zoom, rotation, etc.) and hard touches may be associated with active events such as selections or commands (*e.g.*, button click).

[0109] Fig. 20 illustrates an input device 320 that combines touch sensing and force sensing devices to provide x, y and z components when touched. The touch sensing device provides position sensing in the x and y directions, and the force sensing device provides force sensing in the z direction. These devices cooperate to output x, y location and z pressure information whenever there is a touch on the touch surface.

[0110] Fig. 21 is a side elevation view of an I/O device 330 that combines a display 332 with touch screen 334 and a force sensing mechanism 336. The touch screen 334 provides high resolution touch locations, and the force sensing mechanism 336 provides a measure of where the force is coming from as well the total force. Touch screen 334 is disposed over the display 332, and the force sensing mechanism 336 is disposed below the display 332 although other arrangements are possible.

[0111] Force sensing mechanism 336 may also be widely varied. In the illustrated embodiment, the force sensing mechanism 336 is based on capacitance, and more particularly, self capacitance. The illustrated force sensing mechanism 336 is formed from various layers including an electrode layer 338, an elastomer layer 340 and a conductive layer 342.

[0112] Electrode layer 338 includes a plurality of spatially separated electrodes 339 that are positioned across the bottom of the display 332. Electrodes 339 are typically positioned in an array of rows and columns although often configuring are possible. Any number of electrodes may be used.

[0113] Elastomer layer 340 includes one or more elastic members 341 positioned between the electrode layer 338 and the conductive layer 342. Elastic members 341 allow the display 332 to move inwardly with a limited amount of displacement. In one implementation, elastic members 441 are silicone patches with a thickness of about 0.2 mm.

[0114] Conductive layer 342 typically takes the form of a grounded metal plate 343. A capacitive circuit is formed between each of the electrodes 339 and the grounded metal plate 343. When a user pushes down on the display 332, the force being exerted thereon causes the display 332 to displace inwardly against the elastic members 341 compressing the elastic members. This causes a change in the capacitance between the electrodes 339 and the metal plate 343. This change in capacitance is sensed by a control circuit operatively coupled to each of the electrodes 339. Capacitance sensing circuits are disclosed in the various incorporated references.

[0115] Fig. 22 is a side elevation view of an input device 350 that may be positioned over a display. The input device 350 combines touch sensing and force sensing into a single device. In this embodiment, both the touch sensing and force sensing is provided by mutual capacitance. As shown, the input device 350 is formed from various layers including a top drive layer 352, a middle sense layer 354, and a bottom drive layer 356. Furthermore, the middle sense layer 354 is positioned on an elastomer layer 358 disposed between the middle sense layer 354 and the bottom drive layer 356. The top and bottom drive layers 353 and 356 include a plurality of spatially separated lines in rows and the middle sense layer 354 includes a plurality of spatially separated lines in columns. The top and middle layers 352 and 354 therefore form a grid, and the bottom and middle layers 356 and 354 form a grid.

[0116] During operation, the lines on the top layer 352 are scanned, and thereafter the lines on the bottom layer 356 are scanned (or vice versa). When there is a touch, the mutual capacitance measured between the top drive layer 352 and the middle sense layer 354 provide the x and y location of the touch. In addition, the mutual capacitance measured between the bottom drive layer 356 and the middle sense layer 354 provide the amount of force of the touch. This particular arrangement provides a full image of force superimposed on a full image of touch. The input device including the touch layers and the force layers may be operated similarly to the methods described in U.S. Patent Application No.: 10/840,862, titled "Multipoint Touch Screen," filed on May 6, 2004.

2. Force Sensitive Housing

[0117] The hand-held device may also include a force sensitive housing. The force sensitive housing provides inputs when forces are applied to the housing of the hand-held device. A force sensitive housing is similar to a force sensitive screen in that. The housing provides a slight amount of flex (possibly unnoticeable to the user) so that any forces exerted thereon can be distributed to a force detection arrangement located within the housing. The force detection arrangement monitors the forces on the housing and produces signals indicative thereof. As with the force sensitive display discussed above, the force detection mechanism may include one or more force sensors disposed with in the housing such as force sensitive resistors, force sensitive capacitors, load cells, pressure plates, piezoelectric transducers, strain gauges and/or the like. When a force is applied to the housing (squeezing or pushing on the housing), it is transmitted through the housing to the force sensor located within the housing.

[0118] The force sensitive portions of the housing may be located on any surface of the housing, any side of the housing, any portion of any side of the housing or at dedicated locations on the surface of the housing. The sides of the housing are ideal places for implementing a squeeze feature. This is because the users fingers are typically positioned on one side of the

device and thumb on the other and therefore the hand may easily squeeze the sides via a pinching action. Because it is so convenient to activate the squeeze feature, special care must be taken when designing the squeeze feature so that it will not be accidentally activate during normal use. Thus the device needs to be able to differentiate between light and hard squeezes. If the squeeze feature is implemented using force sensitive resistors (FSRs) which exhibit, a decrease in resistance with an increase in force applied to the active surface a comparator circuit can be used to output a signal to indicate activation when a preset force threshold is reached.

[0119] Fig. 23 is a side view, in cross section, of a hand-held device 370 that incorporates a squeeze feature. As shown, the device 370 includes a housing 372 and a support platform 374 inside the housing 372. Between the support platform 374 and the inner surface of the housing 372 are a pair of force sensors 376. When a force is applied to the housing 372 as for example by the pinching nature of the hand, the housing 372 flexes inwardly under the pressure. This causes the force sensors 376 to be sandwiched between the housing 372 and the support platform 374. The force sensors 376 measure the amount of force being exerted and when a desired force threshold is reached, the force sensors 376 generate a control signal. For example, as a result of being sandwiched, a force resistive sensor may exhibit a reduced resistance and when a desired threshold is reached, a control signal is generated.

[0120] The force sensitive housing may be is provided in conjunction with a touch sensitive housing as discussed above.

E. MOTION ACTUATED INPUT DEVICE

[0121] The hand-held electronic device may also include a motion actuated input device. The motion actuated input device provides inputs when the hand-held device is in motion or is placed in a certain orientation. A motion actuated input device typically includes a motion sensor, such as an accelerometer, that monitors the motion of the device along the x, y, and/or z axis and produces signals indicative thereof. The motion sensor may, for

example, include an accelerometer. Alternatively, the motion sensor could be an orientation sensor, such as an electronic compass, that allows the device to determine its orientation in a generally horizontal plane. The motion sensors may be attached to the housing or to some other structural component located within the housing of the device. When motion is applied to the device (gesturing, shaking, hand waving, etc.), it is transmitted through the housing to the motion sensor.

[0122] Because motion sensors typically measure all motion, not just intended motion, the intended motion information typically must be separated from the other motion information to produce an accurate command signal. For example, large scale movements such as shaking the device will produce primarily low frequency information. Conversely, small scale movements, such as vibrations, primarily produce high frequency information. The high frequency information can be filtered out thereby leaving only low frequency information indicative of the large scale movements (*e.g.*, shaking). The filtered information can then be converted into a control signal.

[0123] Fig. 24 is a side view, in cross section, of a hand-held electronic device 380. The hand-held device 380 includes an accelerometer 382 that is attached to a housing 384 of the hand-held device 380. When the device 380 is moved about by the user, the accelerometer 382 recognizes the motion and a controller of the hand-held electronic device 380 interprets the motion and thereafter performs an action based on the motion event.

F. MECHANICAL ACTUATORS

[0124] While one would like to eliminate all surface mounted actuators such as buttons and wheels, it is sometimes impractical. Therefore the hand-held device may include some number of surface mounted actuators. Preferably, these actuators are generic to each of the integrated devices. That is, their meaning is the same regardless of what device functionality is activated. It is also preferred that the surface mounted actuators be placed on surfaces other than the front surface, which houses the viewing region of the display, although this is not required.

[0125] One particularly useful mechanical actuator is a hold switch. The hold switch may be configured to activate and deactivate the primary input means, *e.g.*, the touch screen. This permits a user to prevent unwanted entries, for example, when the device is stored inside a user's pocket. In one implementation, the hold switch may be placed on the top surface out of the way of the grasping hand, but in a position for easy access (as opposed to the bottom surface). The hold switch can not only deactivate the touch screen but also mechanical actuators and other input and other input devices.

[0126] Another particularly useful mechanical actuator is a power switch. When the power switch is turned on, the device is powered up and ready to go. When the power switch is turned off, the device is shut down. In one implementation, the power switch may be placed on the top surface out of the way of the grasping hand, but in a position for easy access (as opposed to the bottom surface).

[0127] Another useful mechanical actuator is a navigation pad. The navigation pad is typically included with many hand-held devices. The functionality of the navigation pad may be changed according to the current operating mode of the device. In the case of a music player, for example, the directional keys may be assigned, play/pause, next, previous, and volume up and down. Other assignable buttons may also be included on the device.

[0128] Still another useful mechanical actuator is a switching actuator. The switching actuator may be configured to change the functionality of the device, *i.e.*, by activating the switching actuator the functionality or state of the device switches from one mode to another. The switching actuator may be widely varied.

[0129] For example, the switching actuator may be a dial or wheel. By incrementally rotating the wheel, the device is incrementally switched from one device to the other (generally in some predetermined order). A full rotation of each device generally cycles through the entire group of integrated devices. The wheel or dial may for example operate like a scroll wheel. Although the placement may be widely varied, the switching wheel may be

placed in the upper region of the sides of the device. By placing the wheel here, a users thumb may be used to easily rotate the wheel. For example, the users thumb may be extended from the grasping action so that the wheel can be rotated.

[0130] Alternatively, the switching actuator may be a button. By repetitively pressing on the button, the device is switched from one device to another (generally in some predetermined order). Although the placement may be widely varied, the switching button may be placed in the upper region of the sides of the device. By placing the button here, a users thumb or index finger may be used to easily press the button.

[0131] The hand-held device may also include any commercially available touch pad. Several examples of touch pads may be found in U.S. Patent Application No.: 10/188,182, titled "Touch Pad for Handheld Device," filed on July 1, 2002, U.S. Patent Application No.: 10/722,948, titled "Touch Pad for Handheld Device," filed on November 25, 2003, and U.S. Patent Application No.: 10/643,256, titled "Movable Touch Pad with Added Functionality," filed on August 18, 2003.

[0132] In another embodiment, the hand-held device may include a scroll wheel. Scroll wheels can be used in each functionality to scroll through a window.

G. MICROPHONE

[0133] The hand-held device may also include a microphone that picks-up audio sounds. The microphone may be used in conjunction with a cell phone to transmit sounds, such as the user's voice. The microphone may also be used to record sounds or enter voice commands into the hand-held device. For example, using voice recognition software, the hand-held device may be able to recognize voice commands and generated control signals associated therewith. The microphone may be placed in the bottom surface of the hand-held device or possible in the front lower bezel. This particular configuration is well suited for picking up a user's voice during a phone call.

H. IMAGE SENSOR

[0134] A hand-held electronic device may also include an image sensor and lens related components so that the hand-held device can operate like a camera. The image sensor may, for example, include a charge coupled device (CCD) camera.

I. INPUT DEVICE FUNCTIONALITY

1. TOUCH GESTURES

[0135] A hand-held electronic device may be designed to recognize touch gestures applied to a touch screen and/or touch sensitive surface of the housing and thereby control aspects of the hand-held electronic device. Gestures are a stylized interaction with an input device that is mapped to one or more specific computing operations. The gestures may be made through various hand and finger motions. Gestures generally comprise a contact chord *e.g.*, one or more fingers, and a motion associated with the chord. Alternatively or additionally, the gestures may be made with a stylus. In all of these cases, the input device *i.e.*, touch screen and/or touch sensitive surface) receive the gestures and a controller of the hand-held electronic device executes instructions to carry out operations associated with the gestures. The hand-held electronic device may include a touch gesture operational program, which may be part of the operating system or a separate application. The gesture operation program generally includes a set of instructions that recognizes the occurrence of gestures and informs one or more software agents of the gestures and/or what action(s) to take in response to the gestures. For example, gestures that can be used are disclosed in greater detail in U.S. Patent Application No: 10/903,964, titled "Gestures for Touch Sensitive Input Devices," filed on July 30, 2004, and U.S. Patent Application No.: 11/038,590, titled "Mode-Based Graphical User Interfaces for Touch Sensitive Input Devices," filed on January 18, 2005.

2. 3-D SPATIAL GESTURES

[0136] In accordance with one embodiment, the hand-held electronic device may be designed to recognize 3-D spatial gestures measured by an

accelerometer and to control aspects of the hand-held electronic device based on the 3-D spatial gestures. Spatial gestures are stylized motions of the device itself that are mapped to one or more specific computing operations. The 3-D spatial gestures may be made through various hand and arm motions, such as for example shaking, waving and the like. The accelerometer measures the motion related to the 3-D spatial gestures and a controller recognizes the motion as a 3-D spatial gesture and thereafter executes instructions to carry out operations associated with the 3-D spatial gestures. The hand-held electronic device may include a 3-D spatial gesture operational program, which may be part of the operating system or a separate application. The gesture operation program generally includes a set of instructions that recognizes the occurrence of gestures and informs one or more software agents of the gestures and/or what action(s) to take in response to the gestures.

[0137] One exemplary 3-D gesture is shaking the device. Shaking can cause the hand-held device causes the device to shift between modes or states. Alternatively, shaking the hand-held device can cause a selection event to occur. For example, in the case of a media player, shaking the device may cause the device to randomly select a picture or song in group of pictures or songs. Alternatively, shaking the device may cause the device to select the next picture or song in a sequence of songs.

[0138] Other gestures may include translating or rotating the device. Translating the hand-held device (while it is face up) from side to side may be used to initiate panning or scrolling in the device, or moving the device up and down (while it is face up) may be used to initiate zooming. Rotating the device may be used to cause the device to change modes or states. In some cases, for example, the orientation of the device may correspond to a particular mode. For example, a first mode may be associated with 0 degrees, a second mode may be associated with 90 degrees, a third mode may be associated with 180 degrees and a fourth mode may be associated with 270 degrees. In all these cases, the device can be configured to keep

the displayed portion upright as the device is turned. That is, it maintains an upright image no matter what orientation the device is in.

[0139] The 3-D spatial gestures may even be based on more complex motions such as sign language, writing motions, etc.

3. PERFORM ACTION BASED ON MULTIPLE INPUTS

[0140] Because the device may have multiple input modes, the hand-held device may be configured to receive simultaneous inputs from different inputs devices, and perform actions based on the multiple simultaneous inputs. The inputs that may be combined to produce new commands may be selected from voice, 2-D touch gestures, 3-D spatial gestures, actuators, etc. For example, this feature may be helpful when making calls via voice selection. A caller may verbalize "TOM," which causes the device to dial "TOM" phone number. If "TOM" has multiple phone numbers, a user may combine the verbal command "TOM" with a 3-D spatial gesture such as shaking to select Tom's second phone number. Various other possibilities will be appreciated by those skilled in the art.

4. DIFFERENTIATING BETWEEN LIGHT AND HARD TOUCHES

[0141] As noted above, force sensing in conjunction with touch sensing facilitates two distinct types of interactions, light touches and hard touches. Light touches may be used to perform passive actions such as navigating through content and content manipulation generally without causing a major event to occur. Examples of passive events include moving a cursor, scrolling, panning, etc. Hard touch interactions may be used to select on screen buttons or initiate commands (*e.g.*, causes a significant change to occur).

[0142] Fig. 25 is a diagram of a touch method 400for implementing this technique. The method 400 begins at block 402 where one or more touches are detected. The touches include not only x any y components but also z components. The x and y components may be supplied by a touch sensing device such as touch screen, touch pad, or touch housing. The z component

may be provided by force sensors or display actuators located behind the touch surface of the touch sensing device.

[0143] Following block 402, the method proceeds to block 404 where a determination is made as to whether the touch is a light or hard touch. The determination is generally based on the force or pressure of the touch (z component). For example, if the force of the touch is smaller than a predetermined threshold then the touch is considered a light touch and if the force of the touch is larger than the predetermined threshold then the touch is considered a hard touch. If it is determined that the touch is a light touch, the method proceeds to block 406 where a passive action associated with the touch is initiated. If it is determined that the touch is hard touch, an active action associated with the touch is performed (block 408).

[0144] The touch method may additionally include a block where the one or more touches are classified as a primary touch or a secondary touch. Primary touches are touches that are intended to cause an action while secondary touches are touches that are not intended to cause an action. Gestures are examples of primary touches while a thumb positioned over the touch area to hold the device is an example of a secondary touch. Once the touches are classified as primary or secondary, the secondary touches are filtered out, and the determination of whether a touch is a light or hard touch is made with the primary touches.

5. EXAMPLE OF A NEW TOUCH VOCABULARY

[0145] The z pressure exerted on a touch sensing device can be combined with the x and y locations of the touch to form a new touch vocabulary. As should be appreciated, up to this point touch vocabularies have only included x and y locations, not z pressure. A proposed touch vocabulary includes variety of variables including the UI mode, the force of the touch (*e.g.*, light or hard), the number of fingers used, whether or not there is any movement during the touch, the duration of the touch, and the touch location, all or some of which can be combined to form a variety of behaviors and user feedback.

[0146] The UI mode is generally related to the mode or state of the device. Each device includes a variety of states and each state may require a different UI mode. A media player (a mode) may, for example, include a set of hierarchal layers (states) with each layer requiring a different UI.

[0147] As noted above, the force of the touch may, for example, be described as light or hard. A light touch may occur when a user lightly touches the surface of the touch surface, *i.e.*, the finger hovers on top of the surface and is primarily moved in the x and y directions. A hard touch may occur when a user presses on the touch surface with a certain amount of force, *i.e.*, the finger is primarily moved in the z direction against the touch surface.

[0148] Motion during the touch is used to describe whether the finger has remained stationary during a touch event or has substantially moved in the X–Y plane (*e.g.*, translation, rotation, etc.). The motion may be described as none at all or a swipe or twist in some particular direction. By way of example, the swipe may be up, down, right, left, or some combination thereof, and the twist may be clockwise or counterclockwise.

[0149] Duration is defined as the amount of time the finger stays at any one point. Duration may be variable or it may include states such as short and long. The touch location may be a random point or a specific location such as an onscreen button.

[0150] Fig. 26 is an additional touch method 500 implementing this technique. The method begins at block 502 when one or more touches are detected. Thereafter, in block 504, the UI mode is determined. In block 506, a determination is made as to whether the touches are light touches or hard touches. Alternatively, blocks 502 and 504 could be reversed, effectively resulting in an instance of the touch method for each mode. In block 508, the number of distinct touches (*e.g.*, fingers) is determined. In block 510, a determination is made as to whether the touches are stationary or in motion. In block 512, the duration of the touches is determined. In block 514, the locations of the touches are determined. Following blocks 502–514, the method proceeds to block 516 where an action is performed based on the UI

mode, the pressure of the touch, the number of touches, whether or not the touch is moving, the duration of the touch, and the touch location. The actions may be passive or active depending on the values of each characteristic.

[0151] One example of a touch vocabulary associated with a music player is shown in Figs. 27A-E.

V. OUTPUT DEVICES

A. DISPLAY

[0152] The principle output of a hand-held electronic device is typically a display. The display provides visual information in the form of text, characters or graphics. The display is usually a flat panel device although other types of displays may be used. The display may be a liquid crystal display (LCD) such as a character LCD that is capable of presenting text and symbols or a graphical LCD that is capable of presenting images, video, and graphical user interfaces (GUI). Alternatively, the display may correspond to a display based on organic light emitting diodes (OLED), or a display that is based on electronic inks.

[0153] Preferably, the display may be configured to substantially fill the front surface of the housing. The display may extend from one edge of the housing to the opposite edge of the housing, the housing may include a small bezel that surrounds the edges of the display. In either case, the display makes up a substantial portion of the front surface of the hand-held electronic device, thereby eliminating any space for buttons or switches associated with a conventional user interface.

[0154] As mentioned above, besides outputting visual information, the display may also act like an input device. For example, a touch screen may be positioned over the display, and/or sensors may be disposed underneath the display to sense when the device is pressed or otherwise moved. In most cases, the small form factor of hand-held devices requires central placement of the input interfaces to permit operation while being carried around and

used by the hand. The display region provides a central location, which can be accessed by both the left and right hands.

[0155] The display region may be formed by more than one display. For example, the display region may be formed by a pair of displays that are side by side or one on top of the other. A first display may be used to present the standard screen and a second display may be used to present the control screen as described above with reference to Figs. 5–8. Furthermore, a first display may be a conventional display while the second display may be a display actuator. Moreover, a first display may comprise of a first type and a second display may be of a second type. For example, the first display may be an LCD while the second display may be a display based on electronic inks.

[0156] The decision to use different types may be based on the fact that one of the displays may be dedicated to a standard viewing area while another may be dedicated to a control area. Because these two areas require different resolutions, a higher resolution screen may be used in the standard area while a lower resolution screen may be used in the control area. Alternatively or additionally, one of the displays may be selected to reduce battery consumption especially in the control area where lower resolution is acceptable. In some cases, although two different displays are used, the images displayed thereon may be combined to form a single unified image.

B. SPEAKER

[0157] A hand-held device may also include a speaker. Speakers are components that accept electronic signals representing audio information from an amplifier and converts them into sound waves. The speakers may be used to listen to music in conjunction with a music player functionality or to listen to an incoming call in conjunction with a cell phone functionality. The speaker may be placed on the top surface or possible on the front top bezel of the hand-held device. This arrangement works particularly well when the device is used as a cell phone.

C. INDICATOR (LED)

[0158] A hand-held device may also include one or more indicators that provide user feedback or indicate events associated with the device. The events may relate to signals, conditions or status of the device. For example, the indicators provide status of battery life or alert a user when there is an incoming call. The indicators, which include light sources such as light emitting diodes (LED), are typically illuminated when an event occurs, and not illuminated when the event is stopped. Furthermore, the indicator may turn on and off (blink) or cycle with increasing or decreasing intensity, and in some cases may even change colors in order to provide more detailed information about the event that is being monitored.

[0159] The indicators may be conventional indicators that typically include a small clear plastic insert, which is located in front of the LED, and which is inserted within an opening in the housing thus causing it to exist at the surface of the housing. The LED itself may also be placed in the opening in the housing rather than using an insert. Alternatively, the indicator can be configured not to break the surface of the housing. In this configuration, the light source is disposed entirely inside the housing, and is configured to illuminate a portion of the housing thereby causing the housing to change its appearance, *i.e.*, change its color.

D. AUDIO/TACTILE FEEDBACK DEVICES

[0160] The hand-held device may include speakers or buzzers to give audio feedback to the user. These may work similarly to the indicators described above, or they may be used to enhance the feel of actuating a GUI element such as a soft button or scroll wheel. For example, the speaker may be configured to output a "clicking" noise when a user presses on a virtual button, or rotates a virtual scroll wheel. This particular feature enhances the user experience and makes the virtual UI feel more like a physical UI.

[0161] The hand-held device may also include a haptics mechanism. Haptics is the science of applying tactile sensation and control to interaction with computer applications. Haptics essentially allows a user to feel information, *i.e.*, signals are sent to the hand. The haptics mechanisms may

be widely varied. They may include motors, vibrators, electromagnets, etc., all of which are capable of providing force feedback in the form of vibration or shaking. The haptics mechanisms may work similarly to the indicators described above (alert), or they may be used to enhance the feel of actuating a GUI element such as a soft button or scroll wheel. For example, the haptics mechanism may be configured to vibrate when a user presses on a virtual button, or rotates a virtual scroll wheel. This particular feature enhances the users experience and makes the virtual UI feel more like a physical UI. Haptics may also be used simultaneously with onscreen actions. For example, during movies or game playing, the haptics mechanism can simulate the action being displayed. For example, the haptics mechanism may provide force feedback in the form of vibration when a car explodes during a movie or game.

[0162] In cases where haptics is used to enhance the feel of actuating a GUI element, such as a soft button or scroll wheel, the haptics mechanism may be located in the region of the display and further underneath the display so as to provide force feedback directly underneath the user action. In fact, multiple haptics mechanisms may be used regionally across the display to further enhance the feel. It is generally believed that the closer the vibration is to the user action, the greater the haptics effect. In one implementation, the haptics mechanisms are spaced out in an array underneath the display. That is, they are spatially separated and placed at different locations. By way of example, they may be positioned in a 2x2, 2x4, 4x4, 4x8, 8x8 array and so on underneath the display.

[0163] Audio and/or tactile feedback may be used to alert a user that a user input has been made. For example, in response to touching a virtual button on the GUI, the haptics may provide force feedback in the form of vibration and the speaker may provide audio feedback in the form of a click. The tactile audio feedback can be used in conjunction with an input event including touch events, motion events, squeeze events. The feedback may provide information so that the user knows that they actually implemented an input (simulates the audio and tactile feel of a button or switch). In one

implementation, the feedback is tied to the level of force being applied to the force sensing devices. For example, when a certain force threshold is reached, the audio feedback device may create a "click" on the press and a "clock" on the release. The force threshold used may be similar to the threshold used to determine whether a touch is a light or hard touch. The "click" and "clock" may be used to simulate a button click when a hard touch is made.

VI. COMMUNICATION DEVICES

A. WIRED

[0164] The hand-held device may also include one or more connectors for receiving and transmitting data to and from the device. By way of example, the device may include one or more audio jacks, video jacks, data ports, docking ports, etc. The hand-held device may also include one or more connectors for receiving and transmitting power to and from the hand-held device.

[0165] The hand-held device may include a headphone/microphone jack and a data port. The jack is capable of receiving a speaker and/or microphone plug so that audio may be input to and output from the device. The data port is capable of receiving a data plug/cable assembly configured for transmitting and receiving data to and from a host device, such as a general purpose computer (*e.g.*, desktop computer, portable computer). For example, the data port may be used to upload or download data to and from the hand-held device. Such data may include songs and play lists, audio books, e-books, photos, address books, documents, appointments, etc. into the hand-held device. The data port may be a PS/2 port, serial port, parallel port, network interface port, USB port, Firewire port etc. The hand-held device may also include a power port that receives a power plug/cable assembly configured for delivering powering to the hand-held device. In some cases, the data port may serve as both a data and power port by employing either standard or proprietary connectors.

B. WIRELESS

[0166] To send and receive data wirelessly, the device generally requires a transmitter, a receiver (or a transceiver) and some sort of antenna. The wireless communication link may correspond to Bluetooth, WiFi (802.11), IR (infrared), etc. The antenna may be fully contained within the device or they may extend outside the device. The antenna may take a variety of forms depending on the frequency to be used, etc. For example be a rugged rubber duck that consists of a coiled up element encased in rubber. Alternatively, the antenna may be printed on a circuit board within the device.

[0167] The hand-held device may also include a radio transceiver for communications via a cellular network or a GPS receiver.

C. CHANGE UI BASED ON RECEIVED COMMUNICATION SIGNALS

[0168] A hand-held electronic device may be configured to actively look for signals in the surrounding environment, and change its mode based on the signal. That is, the device tries to match the mode with the signal. If the device receives a phone signal over the cellular network, the device may turn into a phone, i.e., the phone mode is activated or brought forward relative to the other modes. If a device receives an email, the device may turn into an email terminal. As another example, when a user walks into a home theater room, the device may sense signals from the media control unit and turn itself into a remote control including functionality to control the various devices of the home theater (TV, amp, DVD, lighting). In other cases, the device may sense signals, which are being broadcast in physical stores, and turn itself into a device that is well suited for that store. For example, in a bank, the device may change into a calculator or bring a money program into view, or in a grocery store, the device may turn into a money payment device or bring a grocery list into view.

VII. OTHER COMPONENTS OF HAND-HELD DEVICE

[0169] The hand held device may additionally include one or more of the following hardware components: a controller (*e.g.*, microprocessor, DSP,

A/D, D/A, converters, codes), memory (*e.g.*, RAM, ROM, solid state (flash), hard disk (micro-drive)), storage (SD card slots, mini-DVD), battery (*e.g.*, lithium ion), etc.

VIII. OVERALL BLOCK DIAGRAM

[0170] Fig. 28 is a block diagram of an exemplary hand-held device 600. The hand-held device 600 typically includes a controller 602 (*e.g.*, CPU) configured to execute instructions and to carry out operations associated with the hand-held device. For example, using instructions retrieved for example from memory, the controller 602 may control the reception and manipulation of input and output data between components of the hand-held device 600. The controller 602 can be implemented on a single chip, multiple chips or multiple electrical components. For example, various architectures can be used for the controller 602, including dedicated or embedded processor, single purpose processor, controller, ASIC, etc. By way of example, the controller may include microprocessors, DSP, A/D converters, D/A converters, compression, decompression, etc.

[0171] In most cases, the controller 602 together with an operating system operates to execute computer code and produce and use data. The operating system may correspond to well known operating systems such as OS/2, DOS, Unix, Linux, and Palm OS, or alternatively to special purpose operating system, such as those used for limited purpose appliance-type devices. The operating system, other computer code and data may reside within a memory block 604 that is operatively coupled to the controller 602. Memory block 604 generally provides a place to store computer code and data that are used by the hand-held device. By way of example, the memory block 604 may include read-only memory (ROM), random-access memory (RAM), hard disk drive (*e.g.*, a micro drive), flash memory, etc. In conjunction with the memory block 604, the hand-held device may include a removable storage device such as an optical disc player that receives and plays DVDs, or card slots for receiving mediums such as memory cards (or

memory sticks). Because the form factor of the hand-held device is small, the optical drive may only be configured for mini DVDs.

[0172] The hand-held device 600 also includes various input devices 606 that are operatively coupled to the controller 602. The input devices 606 are configured to transfer data from the outside world into the hand-held device 600. As shown, the input devices 606 may correspond to both data entry mechanisms and data capture mechanisms. In particular, the input devices 606 may include touch sensing devices 608 such as touch screens, touch pads and touch sensing surfaces, mechanical actuators 610 such as button or wheels or hold switches (611), motion sensing devices 612 such as accelerometers, force sensing devices 614 such as force sensitive displays and housings, image sensors 616, and microphones 618. The input devices 606 may also include a clickable display actuator 619.

[0173] The hand-held device 600 also includes various output devices 620 that are operatively coupled to the controller 602. The output devices 620 are configured to transfer data from the hand-held device 600 to the outside world. The output devices 620 may include a display 622 such as an LCD, speakers or jacks 624, audio/tactile feedback devices 626, light indicators 628, and the like

[0174] The hand-held device 600 also includes various communication devices 630 that are operatively coupled to the controller 602. The communication devices 630 may, for example, include both wired and wireless connectivity selected from I/O ports 632 such as IR, USB, or Firewire ports, GPS receiver 634, and a radio receiver 636.

[0175] The hand-held device 600 also includes a battery 650 and possibly a charging system 652. The battery may be charged through a transformer and power cord or through a host device or through a docking station. In the cases of the docking station, the charging may be transmitted through electrical ports or possibly through an inductance charging means that does not require a physical electrical connection to be made.

[0176] The various aspects, features, embodiments or implementations of the invention described above can be used alone or in various

combinations. The methods of this invention can be implemented by software, hardware or a combination of hardware and software. The invention can also be embodied as computer readable code on a computer readable medium. The computer readable medium is any data storage device that can store data which can thereafter be read by a computer system, including both transfer and non-transfer devices as defined above. Examples of the computer readable medium include read-only memory, random access memory, CD-ROMs, flash memory cards, DVDs, magnetic tape, optical data storage devices, and carrier waves. The computer readable medium can also be distributed over network-coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

[0177] While this invention has been described in terms of several preferred embodiments, there are alterations, permutations, and equivalents, which fall within the scope of this invention. It should also be noted that there are many alternative ways of implementing the methods and apparatuses of the present invention. It is therefore intended that the following appended claims be interpreted as including all such alterations, permutations, and equivalents as fall within the true spirit and scope of the present invention.

CLAIMS

What is claimed is:

1. A hand-held electronic device, comprising:
   a multi-touch input surface; and
   a processing unit operatively connected to said multi-touch input surface, said processing unit capable of receiving a plurality of concurrent touch inputs from a user via said multi-touch input surface and discriminating a user requested action from the touch inputs; and
   a display device operatively coupled to the processing unit and configured to present a user interface.

2. A hand-held electronic device as recited in claim 1, wherein said hand-held electronic device is includes two or more of the following device functionalities: PDA, mobile phone, music player, camera, video player, game player, handtop, Internet terminal, GPS receiver, and remote control.

3. A hand-held electronic device as recited in claim 1, wherein said hand-held electronic device is capable of reconfiguring or adapting the user interface based on the state or mode of said hand-held electronic device.

4. A hand-held electronic device as recited in claim 3, wherein said display device is a full screen display.

5. A hand-held electronic device as recited in claim 1, wherein said multi-touch input surface is integral with said display device.

6. A hand-held electronic device as recited in claim 5, wherein said hand-held electronic device is includes two or more of the following device functionalities: PDA, mobile phone, music player, camera, video player, game player, camera, handtop, Internet terminal, GPS receiver, and remote control.

7. A hand-held electronic device as recited in claim 5, wherein said multi-touch input surface serves as the primary input means necessary to interact with said hand-held electronic device.

8. A hand-held electronic device as recited in claim 7, wherein said hand-held electronic device includes cross-functional physical buttons.

9. A hand-held electronic device as recited in claim 5, wherein said the multi-touch input surface integral with the display device is a multi-point capacitive touch screen.

10. A hand-held electronic device as recited in claim 9, wherein said hand-held electronic device is operable to recognize touch gestures applied to said multi-touch input surface wherein the touch gestures are used to control aspects of said hand-held electronic device.

11. A hand-held electronic device as recited in claim 1, wherein said hand-held electronic device is operable to receive simultaneous inputs from different inputs devices and perform actions based on the simultaneous inputs.

12. A hand-held electronic device as recited in claim 1, wherein signals from various input devices of said hand-held electronic device have different meanings or outputs based on a mode of said hand-held electronic device.

13. A hand-held electronic device as recited in claim 1, wherein said user interface comprises a standard region and a control region the standard region being used to display data, and the control region including one or more virtual controls for user interaction.

14. A hand-held electronic device as recited in claim 13, wherein at least one of the standard region and the control region are user configurable.

15. A hand-held electronic device as recited in claim 1, wherein said display device comprises a force sensitive display, said force sensitive display producing one or more input signals to be generated when force is exerted thereon.

16. A hand-held electronic device as recited in claims 15, wherein said force sensitive display senses a force indication, and wherein said hand-held electronic device distinguishes the force indication into at least a first touch type and a second touch type.

17. A hand-held electronic device as recited in any of claim 16, wherein the first touch type corresponds to a light touch, and the second touch type corresponds to a hard touch.

18. A hand-held electronic device as recited in claim 1, wherein said hand-held electronic device provides audio or tactile feedback to a user based on user inputs made with respect to said hand-held electronic device.

19. A hand-held electronic device as recited in claim 1, wherein hand-held electronic device is configurable to actively look for signals in a surrounding environment, and change user interface or mode of operation based on the signals.

20. A hand-held computing device, comprising:

a housing;

a display arrangement positioned within said housing, said display arrangement including a display and a touch screen; and

a device configured to generate a signal when some portion of said display arrangement is moved.

21. A hand-held electronic device, comprising:

a touch screen; and

a processing unit operatively connected to said touch screen, said processing unit concurrently receives a plurality of touch inputs from a user via said touch screen and discriminates a user requested action from the touch inputs,

wherein said touch screen serves as the primary input means necessary to interact with said hand-held electronic device.

22. A hand-held electronic device as recited in claim 21, wherein said media device operates as one or more of a mobile phone, a PDA, a media player, a camera, a same player, a handtop, an Internet terminal, a GPS receiver, or a remote controller.

23. A method performed in a computing device having a display and a touch screen positioned over the display, the method comprising:

detecting one or more touches;

classifying the one or more touches as a primary touch or a secondary touch;

filtering out the secondary touches;

differentiating whether the primary touch is a light touch or a hard touch;

initiating a control event if the primary touch is a light touch; and

implementing a selection event if the primary touch if a hard touch.

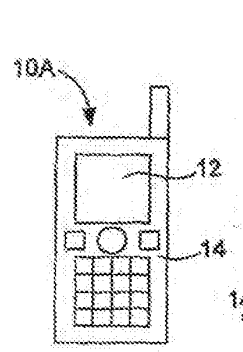


FIG. 1A

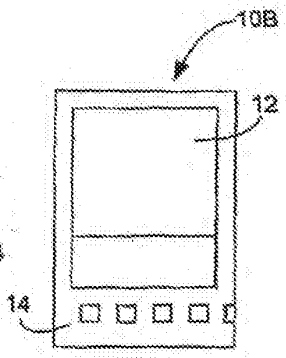


FIG. 1B

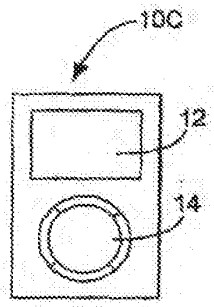


FIG. 1C

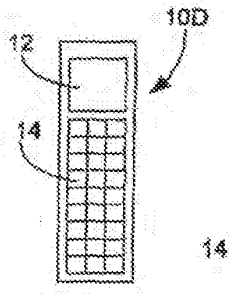


FIG. 1D

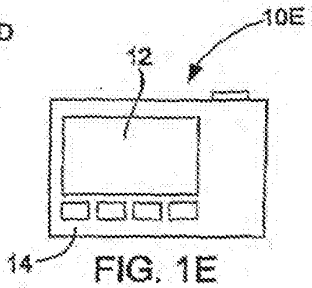


FIG. 1E

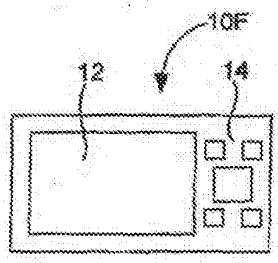


FIG. 1F

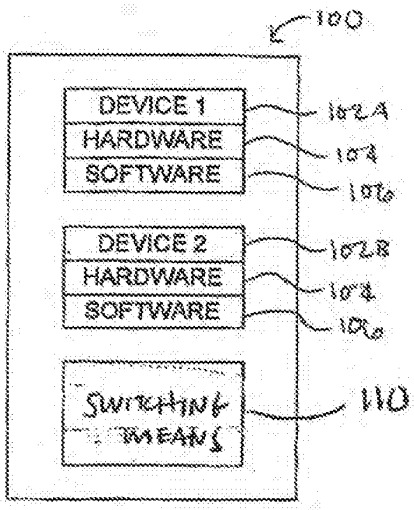

100
DEVICE 1
HARDWARE
SOFTWARE
102A
104
106
DEVICE 2
HARDWARE
SOFTWARE
102B
104
106
SWITCHING MEANS
110

FIG. 2

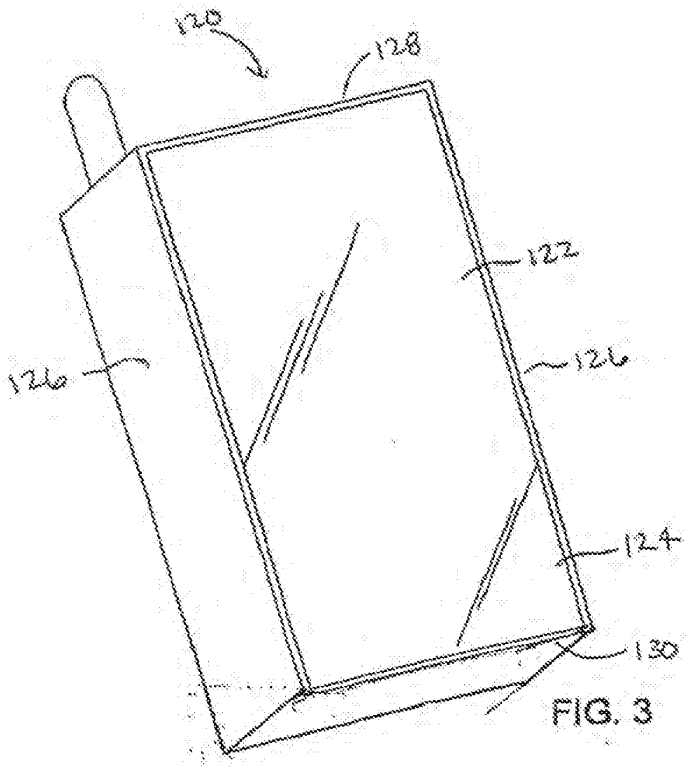

120
128
122
126
126
124
130

FIG. 3

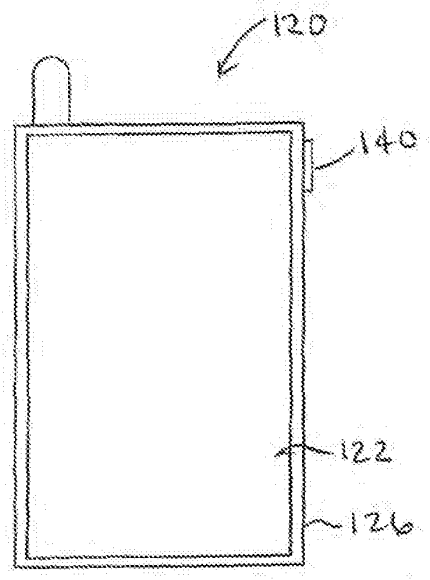


FIG. 4

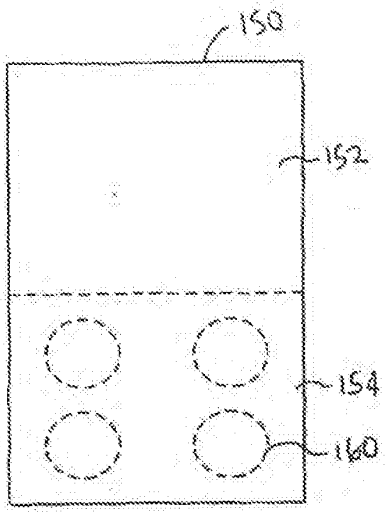


FIG. 5

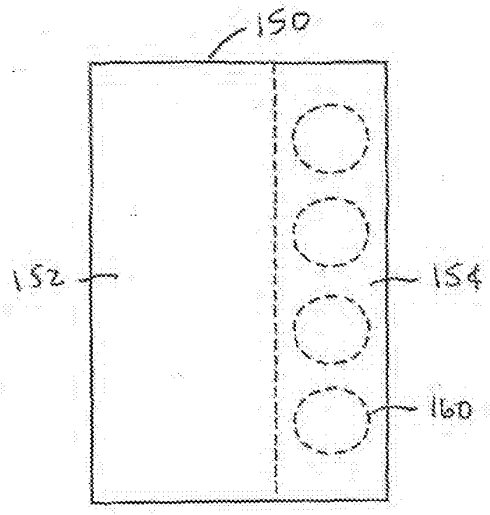


FIG. 6

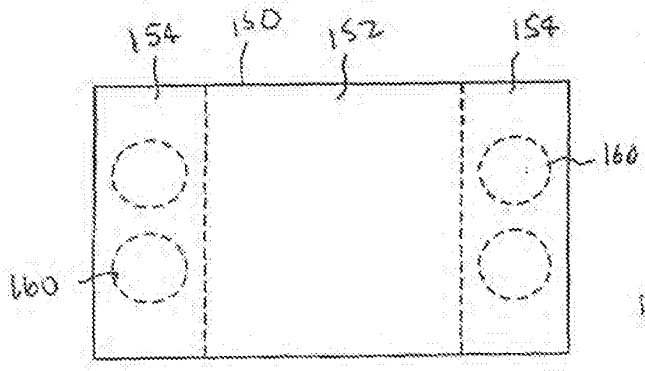


FIG. 7

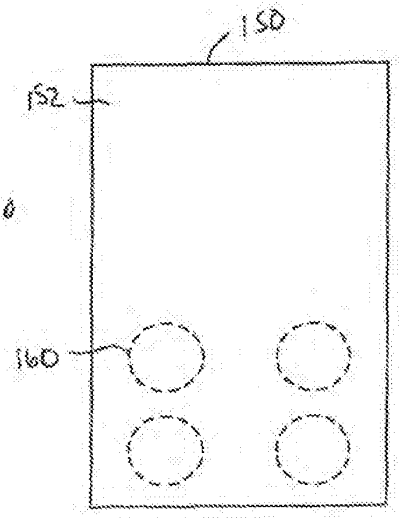


FIG. 8

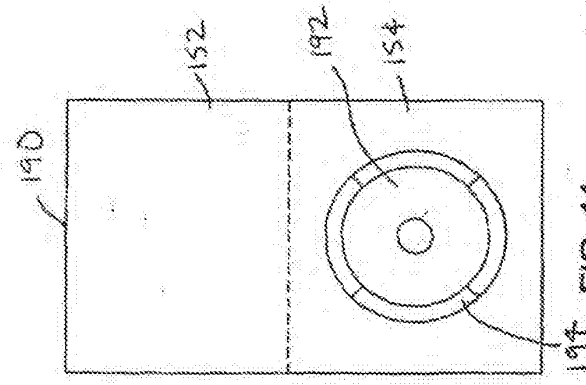


FIG. 11

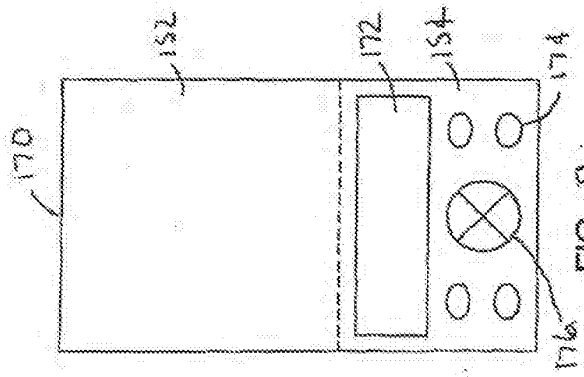


FIG. 9

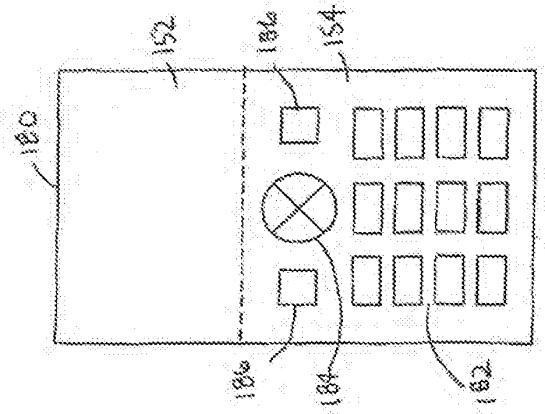


FIG. 10

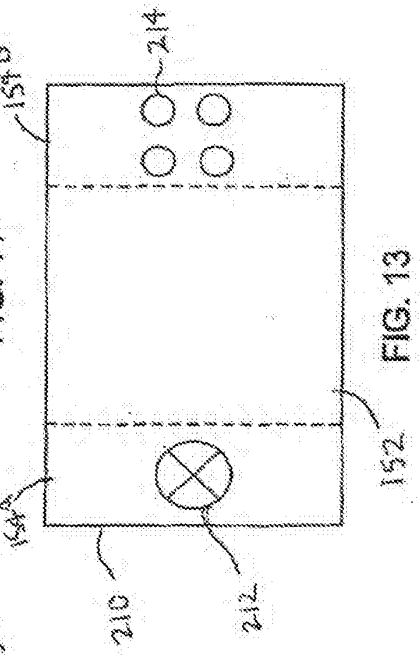


FIG. 13

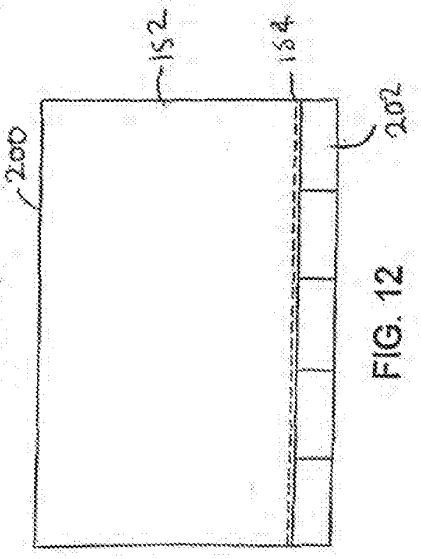


FIG. 12

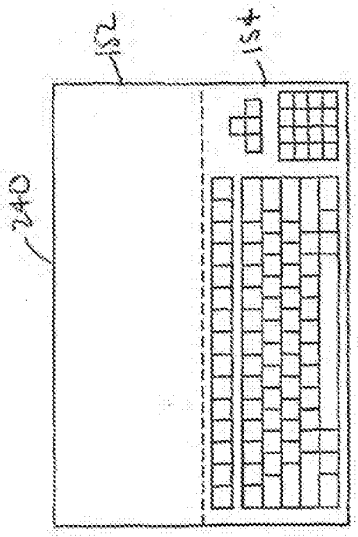


FIG. 16

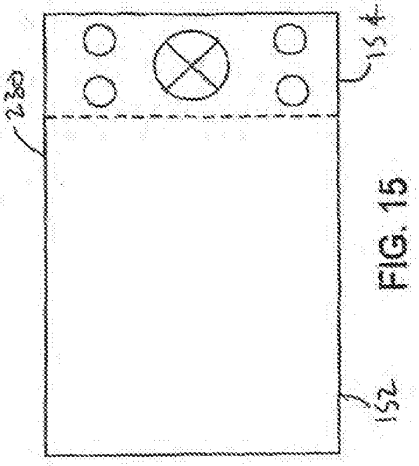


FIG. 15

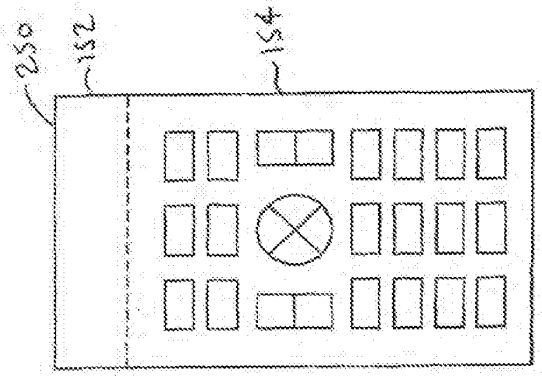


FIG. 17

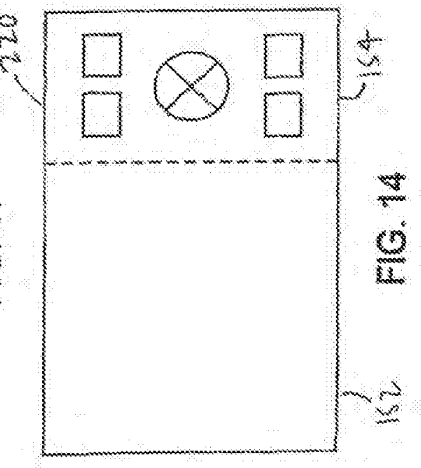


FIG. 14

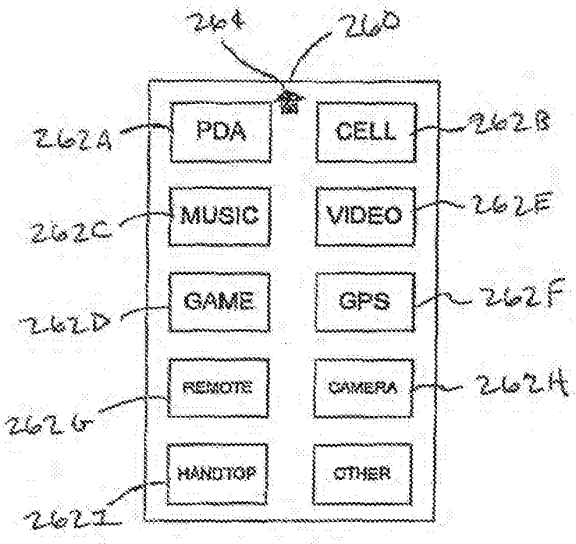

264
260
262A
PDA
CELL
262B
MUSIC
VIDEO
262E
262C
GAME
GPS
262F
262D
REMOTE
CAMERA
262H
262G
HANDTOP
OTHER
262I

FIG. 18

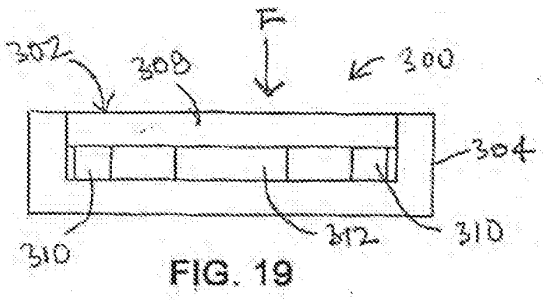


FIG. 19

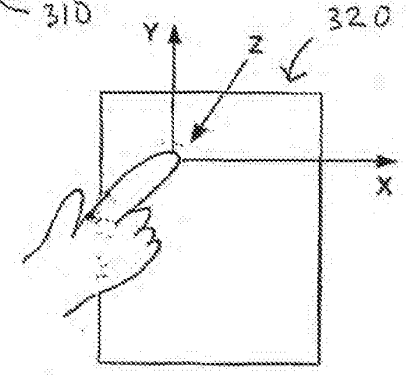


FIG. 20

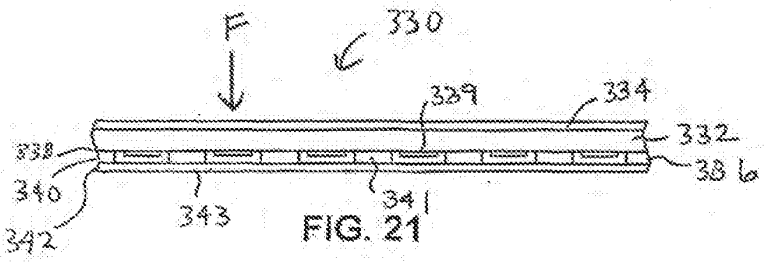


FIG. 21

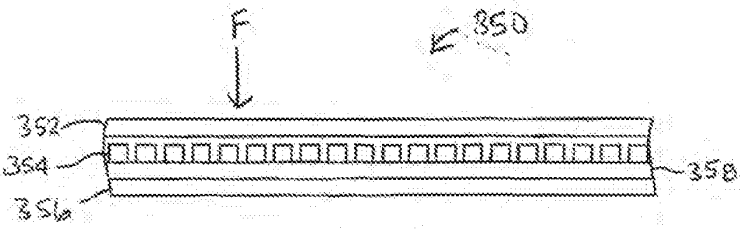


FIG. 22

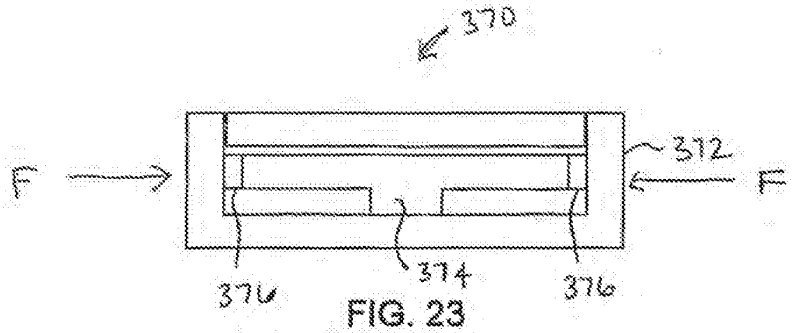


FIG. 23

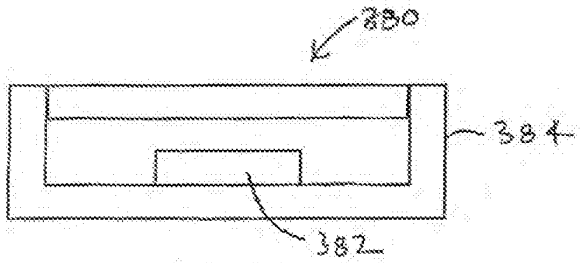


FIG. 24

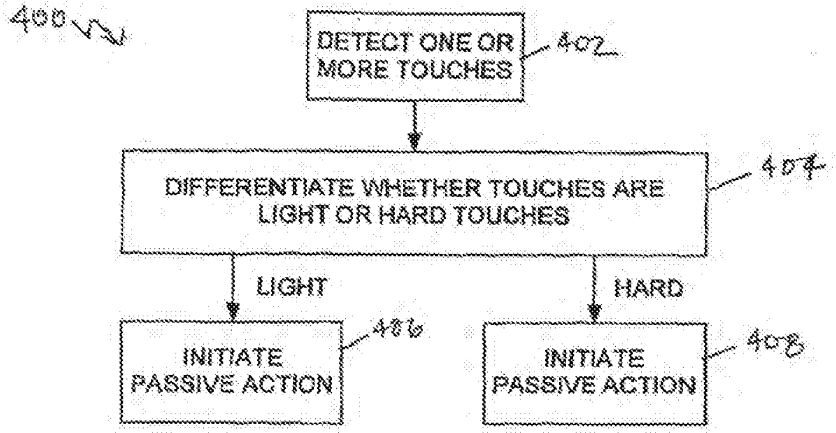

400
DETECT ONE OR MORE TOUCHES
402
DIFFERENTIATE WHETHER TOUCHES ARE LIGHT OR HARD TOUCHES
404
LIGHT
HARD
INITIATE PASSIVE ACTION
406
INITIATE PASSIVE ACTION
408

FIG. 25

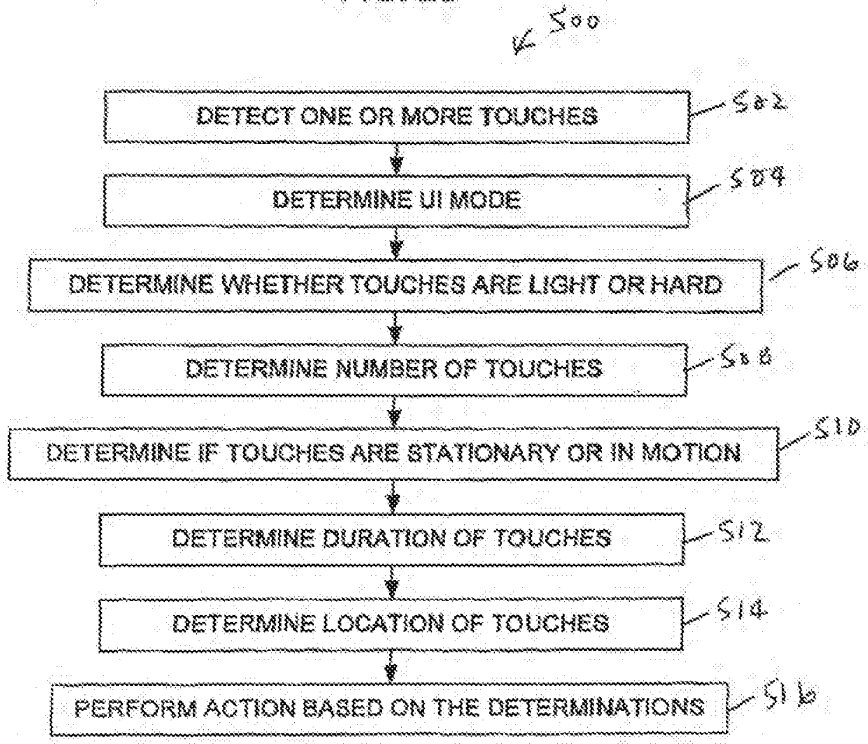

500
DETECT ONE OR MORE TOUCHES
502
DETERMINE UI MODE
504
DETERMINE WHETHER TOUCHES ARE LIGHT OR HARD
506
DETERMINE NUMBER OF TOUCHES
508
DETERMINE IF TOUCHES ARE STATIONARY OR IN MOTION
510
DETERMINE DURATION OF TOUCHES
512
DETERMINE LOCATION OF TOUCHES
514
PERFORM ACTION BASED ON THE DETERMINATIONS
516

FIG. 26

#	UI Mode	Light Touch or Tactile Click	# Fingers used	Movement during touch or click	Duration	Touchdown location (virtual button?)	Proposed Behavior	Feedback
Basic list navigation								
	List Nav.	light	1	none	any	anywhere	On touch-down, do nothing. On lift-off, highlight item(if any) under touch	highlight item touched
	List Nav.	click	1	NONE	short	virtual button / list item	On touch-down, do nothing. On click-down highlight item under touch (if any). On un-click, execute the item clicked	animate screen sliding RIGHT to expose new screen
	List Nav.	click	1	NONE	short	PLAY / PAUSE virtual button	On touch-down, do nothing. On click-down highlight Play/Pause icon. On un-click, PLAY/PAUSE	Change PLAY/PAUSE icon
	List Nav.	click	1	NONE	LONG	virtual button	On touch-down, do nothing. On click-down highlight item under touch (if any). After delay, bring-up context sensitive menu.	Context sensitive menu pop-up
	List Nav.	light or click	1	UP/DOWN	any	anywhere	On touch-down, do nothing. Scroll list UP/DOWN depending on UP/DOWN distance moved, use inertia & brakes, disregard LEFT/RIGHT motion during gesture. If highlighted item slides off visible screen, change highlighted item to one that is visible.	list scrolling UP/DOWN, first few letters enlarged
	List Nav.	light or click	1	LEFT	any	anywhere	On touch-down, do nothing. On left motion, open highlighted folder or execute highlighted item (like legacy SELECT button)	animate screen sliding LEFT
	List Nav.	light or click	1	RIGHT	any	anywhere	On touch-down, do nothing. On right motion, go back out a folder (like legacy MENU function)	animate screen sliding RIGHT

Fig. 27A

#	UI Mode	Light Touch or Tactile Click	# Fingers used	Movement during touch or click	Duration	Touchdown location (virtual button?)	Proposed Behavior	Feedback
2D photo thumnail preview / navigation								
	photo preview	light	1	none	any	anywhere	On touch-down, do nothing. On lift-off, highlight item(if any) under touch	highlight item touched
	photo preview	click	1	NONE	short	virtual button / thumbnail	On touch-down, do nothing. On click-down highlight item under touch (if any). On un-click, execute the item clicked	animate screen sliding RIGHT to expose new screen
	photo preview	click	1	NONE	short	PLAY / PAUSE virtual button	On touch-down, do nothing. On click-down highlight Play/Pause icon. On un-click, PLAY/PAUSE	Change PLAY/PAUSE icon
	photo preview	click	1	NONE	LONG	virtual button	On touch-down, do nothing. On click-down highlight item under touch (if any). After delay, bring-up context sensitive menu.	Context sensitive menu pop-up
	photo preview	light or click	1	UP/DOWN	any	anywhere	On touch-down, do nothing. Scroll list of thumbnails UP/DOWN depending on UP/DOWN distance moved, use inertia & brakes, disregard LEFT/RIGHT motion during gesture. If highlighted item slides off visible screen, change highlighted item to one that is visible.	list of thumbnails scrolling UP/DOWN
	photo preview	light or click	1	LEFT	any	anywhere	On touch-down, do nothing. On left motion, open highlighted folder or execute highlighted item (like legacy SELECT button)	animate screen sliding LEFT
	photo preview	light or click	1	RIGHT	any	anywhere	On touch-down, do nothing. On right motion, go back out a folder (like legacy MENU function)	animate screen sliding RIGHT

Fig 27B

WO 2006/094308 PCT/US2006/008349 12/16

#	UI Mode	Light Touch or Tactile Click	# Fingers used	Movement during touch or click	Duration	Touchdown location (virtual button?)	Proposed Behavior	Feedback
Now Playing								
	Now Playing	light	1	none	any	anywhere	do nothing	n/a
	Now Playing	click	1	NONE	any	anywhere	On touch-down, do nothing. On click-down PLAY / PAUSE.	change PLAY/PAUSE icon
	Now Playing	light	1	UP/DOWN	any	anywhere	do nothing	n/a
	Now Playing	light	1	LEFT	any	anywhere	do nothing	n/a
	Now Playing	light	1	RIGHT	any	anywhere	On touch-down, do nothing. On right motion, go back out a folder (like legacy MENU function)	animate screen sliding RIGHT
	Now Playing	click	1	UP/DOWN	any	anywhere	On touch-down & click-down, do nothing. On UP/DOWN motion detect, increase/decrease volume and disregard LEFT/RIGHT motion	Volume slider moves UP/DOWN
	Now Playing	click	1	LEFT	any	anywhere	On touch-down & click-down, do nothing. On left motion, go to next track (like legacy NEXT button)	animate screen sliding LEFT
	Now Playing	click	1	RIGHT	any	anywhere	On touch-down & click-down, do nothing. On right motion detect, go to prev. track (like legacy PREV button)	animate screen sliding RIGHT

FIG. 27C

#	UI Mode	Light Touch or Tactile Click	# Fingers used	Movement during touch or click	Duration	Touchdown location (virtual button?)	Proposed Behavior	Feedback
Full-screen Item (Photo, map view, calendar day, single contact view, etc.)								
	Full-screen item	light	1	none	any	anywhere	do nothing	n/a
	Full-screen item	click	1	NONE	any	anywhere	On touch-down, do nothing. On click-down PLAY / PAUSE.	change PLAY/PAUSE icon
	Full-screen item	light	1	UP/DOWN	any	anywhere	do nothing	n/a
	Full-screen item	light	1	LEFT	any	anywhere	do nothing	n/a
	Full-screen item	light	1	RIGHT	any	anywhere	On touch-down, do nothing. On right motion, go back out a folder (like legacy MENU function)	animate screen sliding RIGHT
	Full-screen item	click	1	UP/DOWN	any	anywhere	On touch-down & click-down, do nothing. On UP/DOWN motion detect, increase/decrease volume and disregard LEFT/RIGHT motion	Volume slider moves UP/DOWN
	Full-screen item	click	1	LEFT	any	anywhere	On touch-down & click-down, do nothing. On left motion, go to next item (like legacy NEXT button)	animate screen sliding LEFT
	Full-screen item	click	1	RIGHT	any	anywhere	On touch-down & click-down, do nothing. On right motion detect, go to prev. item (like legacy PREV button)	animate screen sliding RIGHT

FIG. 27D

#	UI Mode	Light Touch or Tactile Click	# Fingers used	Movement during touch or click	Duration	Touchdown location (virtual button?)	Proposed Behavior	Feedback
Optional Multi-touch gestures on full-screen item								
	Full-screen item	light or click	2 or more	Up, down, right, left	any	anywhere	translate image according total incremental centroid translation of contacts, scale (zoom) image according to total incremental spread (radius of gyration) of contacts, rotate image according to incremental rotation of contacts	image translation, scaling and rotation

Fig. 17E

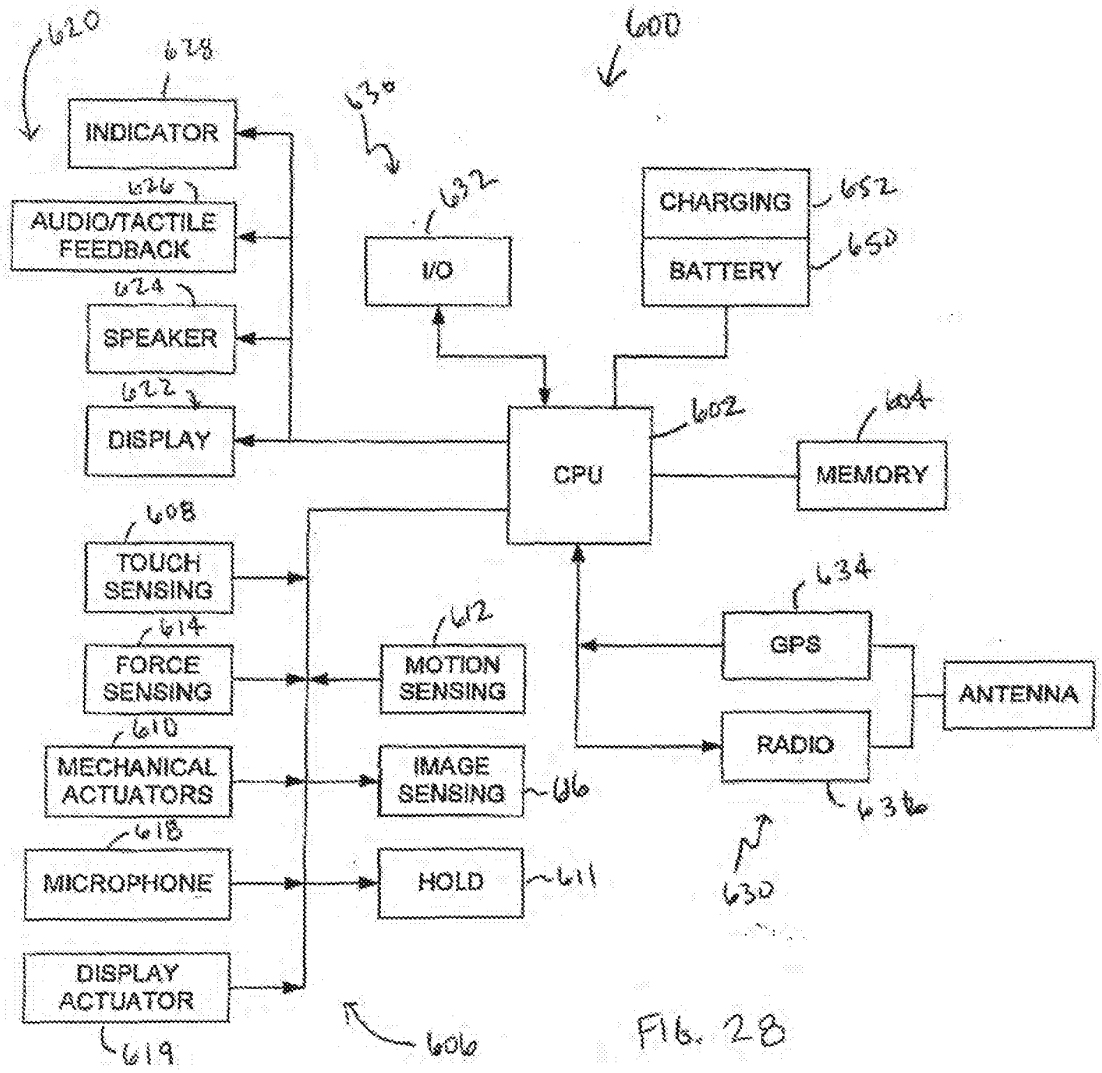

620
628
600
630
INDICATOR
626
AUDIO/TACTILE FEEDBACK
624
SPEAKER
622
DISPLAY
632
I/O
CHARGING
652
BATTERY
650
CPU
602
604
MEMORY
608
TOUCH SENSING
614
FORCE SENSING
610
MECHANICAL ACTUATORS
618
MICROPHONE
DISPLAY ACTUATOR
619
606
612
MOTION SENSING
616
IMAGE SENSING
611
HOLD
634
GPS
ANTENNA
636
RADIO
630

FIG. 28

Full text view | Words to highlight: | submit | Advanced Highlighting

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JP2003084901A2
Title/Abstract
Non Latin text

JP2003084901 A2 Translate to English (via PatBase internal translation) or Select language to translate to (via Google): English Translate

Print Save RWS human translation (fees apply)

Title :

回転式入力装置

Rotary input device

Abstract :

【課題】 選択状況を触覚で認識し、視覚負担を低減させる回転式入力装置を提供する。 【解決手段】 ホイール４２の回転角を、ホイール位置
検出部４４で検出し、検出値が、ホイール制御演算部４５によって、通信部４６から操作・表示処理演算部４７に出力される。操作・表示処理演算部では、回転角に応じて、表示部で表示されているポインタ位置を演算し、ポインタを移動させる。ホイール制御演算部４５では、ホイール４２の回転角に応じて、ポインタの位置に対応したトルクを演算し、演算値をホイール駆動部４３に出力して、ホイール４２に伝達されるトルクを制御する。これによって、ホイールを操作し、ポインタを移動して、表示されている項目を選択する場合は、選択状況を触覚でも認識できるから、視覚負担が低減される。

Recognized by the tactile selection state [PROBLEMS] To provide a rotary input device thereby reduced the burden visually. Detected by the detector 44 wheel position, the angle of rotation of the wheel 42 comprises, by 4 5 wheel control arithmetic unit, the detection value, the operation and display processing operation of the communication unit 46 output to 47 . The operation and display processing operation unit, and Ji corresponding to the rotation angle to calculate the position of the pointer that is displayed on the display unit moves the pointer . The control arithmetic unit 45 wheel, we calculated the force torque depending on the angle of rotation of the wheel 42 was corresponding to the position of the pointer, the drive unit 43 enters the calculated value wheel Te control the torque is transmitted to the wheel 42. This , because we can recognize tactile selection state, if you select the items Te operate the wheel, move the pointer, are visible, visual reduction burden be.

Claim(s) :

1. 複数の項目で構成され、表示部にて表示 された操作対象に対して、ホイールを回転操作すること によって、前記項目を順次に選択する回転式入力装置に おいて、前記ホイールに力を伝達する力発生手段を設け て、前記ホイールに伝達する力を前記選択状況に応じて 変化させることを特徴とする回転式入力装置。

For the operation target by being composed of a plurality of items 1.

, is displayed in the display unit, operated to rotate the wheel, in the rotary input device to select the items sequentially, said wheel rotary input device, which is characterized by varying the selected depending on the situation the force generating means is provided for transmitting a force to the force, transmitted to the wheels.

2. 前記力発生手段は、前記ホイールの回転 方向にトルクを伝達するトルク発生手段であることを特 徴とする請求項１記載の回転式入力装置。

said force generating means 2.

3. 前記操作対象には異なる機能または分類 が設けられており、前記トルク発生手段は、同一の機能 または分類に属する前記項目間で選択を移動する際に、 第１のトルタ・パターンのトルク、機能または分類の切 り替えを伴って前記項目間で選択を移動する際には、第 ２のトルク・パターンのトルクを前記ホイールに伝達す ることを特徴とする請求項２記載の回転式入力装置。

The rotary input device according to claim 1 and characterized in that the torque generating means for transmitting a torque in the direction of rotation of said wheel.

Classification is provided with different functions or the operation target 3.

, when moving the selection between the items belonging to the same features or classification, wherein the torque generating means, a first pattern Torta When you move the selection between the item above in accordance with the torque, changing the polarity of the classification function or, according to claim 2, characterized in that you transmitted to said wheel torque of the torque pattern of the second rotary input device.

4. 操作対象の前記項目が表示画面上で複数 行または複数列をなして表示され、前記トルク発生手段 は、行または列の切り替えを伴って前記項目間で選択を 移動する際に、第３のトルク・パターンのトルクを前記 ホイールに伝達することを特徴とする請求項２または３ 記載の回転式入力装置。

The item to be operated 4.

appears forms multiple rows or columns on a display screen, said torque generating means, when you move between the items selected in the row or column with a switching, the rotary input device according to claim 2 or 3, characterized in that the torque transmitted to said wheel torque third pattern.

5. トルク発生手段は、前記表示画面の切り 替えを伴って、前記項目間で選択を移動する際に、第４ のトルク・パターンのトルクを前記ホイールに伝達する ことを特徴とする請求項２、３または４記載の回転式入 力装置。

When cutting with the sort of the display screen to move between items selected by the generating means 5. torque

is characterized in that the torque transmitted to said wheel torque fourth pattern rotary input device according to claim 2, 3 or 4.

6. 前記第２、３または４のトルク・パター ンは、前記ホイールの回転角に対してトルクが山型に変 化するものであることを特徴とする請求項３、４または ５記載の回転式入力装置。

Torque the second pattern 2, 3 or 4 6.

are to claim 3, 4 or 5, characterized in that the torque will change the rotation angle of the wheel angled with respect to the rotary input device of claim.

7. 前記力発生手段は、前記ホイールに振動 を伝達する振動発生手段であることを特徴とする請求項 １記載の回転式入力装置。

said force generating means 7.

, a rotary input device according to claim 1, characterized in that the vibration generating means for transmitting vibration to the wheel.

8. 前記操作対象には、前記項目の選択範囲 が設定され、前記振動発生手段は、選択範囲を越えて前 記ホイールを操作した際に、前記ホイールに振動を伝達 することを特徴とする請求項７記載の回転式入力装置。

selection of items above are set, when operating the wheel described before beyond selection, subject to the operation 8.

9. 前記操作対象には、異なる機能または分 類が設けられ、前記振動発生手段は、選択した項目の属 性に応じて異なる振動を伝達することを特徴とする請求 項７または８記載の回転式入力装置。

, the means for generating the vibration is characterized by transmitting vibration to said wheel rotary input device

Description :

【０００１】【発明の属する技術分野】本発明は、操作が簡単で、視覚負担を低減できる回転式入力装置に関する。

【０００２】【従来の技術】回転式入力装置としては、例えば特開平１１－３５１８９８号公報記載の「カーナビゲーションシステムの機能選択方法及びリモートコントロール装置」のように、ホイールの回転方向に各種のメニューまたは機能を対応させ、ホイールを回転操作することによって、メニューまたは機能を順次に選択し、ホイールを押し込む操作により選択されているメニューまたは機能が決定されるように構成されるものがあり、従来用いられている２次元ポインティング・デバイスによる選択操作に比べて視覚負荷の低減、操作の簡略化が試みられている。

【０００３】さらに、上記と同じように順次選択を行う別のユーザインタフェースとしては、例えば特開平２００１－１３９７８号公報記載の「情報選択装置、情報選択方法及び記録媒体」のように、複数の音声情報を選択項目に関連付け、順次に選択された項目に対応した音声情報を再生し、所望の選択項目に関連した音声情報が再生された時点で決定操作を実施するものが提供され、上記よりさらに視覚負荷の低減が試みられている。

【０００４】【発明が解決しようとする課題】しかしながら、前者の回転式入力装置にあっては、現在の選択位置を示すポインタの移動方向が進む／戻るの１次元に限定されるため、図１２の（ａ）に示されるように、ポインタｋがｘ、ｙ両方向に自由に移動可能な２次元ポインティング・デバイスによる選択操作に比べて、表示画面を注視する度合いが幾分低減されるものの、図１２の（ｂ）に示されるように、表示項目が１列で終わらない場合、所望の項目を選択するには、ポインタｋの動きを目視で追跡する必要があるため、依然として視覚負荷が大きく、とくにカーナビゲーションシステムなど車載装置への適用に問題があった。

【０００５】また、後者の音声情報を利用した情報選択装置にあっては、選択項目に対応する音声情報を認識するための時間が比較的長いため、操作時間が必然的に長くなり、また、他のシステムからの音声情報が混在する環境下では、誤認する可能性があり、車載装置への適用は困難であるという問題があった。本発明は、上記従来の問題点に鑑み、車載装置、とくにカーナビゲーションシステムなどにおいて、メニューまたは機能の選択を、視覚に負荷をかけずに容易に行える回転式入力装置を提供することを目的とする。

【０００６】【課題を解決するための手段】請求項１記載の発明は、複数の項目で構成され、表示部にて表示された操作対象に対して、ホイールを回転操作することによって、前記項目を順次に選択する回転式入力装置において、前記ホイールに力を伝達する力発生手段を設けて、前記ホイールに伝達する力を前記選択状況に応じて変化させるものとした。

【０００７】請求項２記載の発明は、前記力発生手段が、前記ホイールの回転方向にトルクを伝達するトルク<DP N=0003>発生手段であるものとした。

【０００８】請求項３記載の発明は、前記操作対象には異なる機能または分類が設けられており、前記トルク発生手段は、同一の機能または分類に属する前記項目間で選択を移動する際に、第１のトルク・パターンのトルク、機能または分類の切り替えを伴って前記項目間で選択を移動する際には、第２のトルク・パターンのトルクを前記ホイールに伝達するものとした。

【０００９】請求項４記載の発明は、操作対象の前記項目が表示画面上で複数行または複数列をなして表示され、前記トルク発生手段は、行または列の切り替えを伴って前記項目間で選択を移動する際に、第３のトルク・パターンのトルクを前記ホイールに伝達するものとした。

【００１０】請求項５記載の発明は、トルク発生手段

according to claim 7, said.

subject to the operation 9.

is classified or different functions are provided, means for generating the vibration is 7 or 8, wherein it transmits the vibration varies depending on the attributes of the selected item rotary input device of claim.

The present invention relates to

[0001], easy to operate, on a rotary input device capable of reducing the burden
Visual perception.

For example, function and selection method described in JP-A-Hei
11-351898 of "
car navigation system remote control device as an input device for rotary

[0004],
As in "position,
I'll be made to correspond to function, operated to rotate the wheel, the menus of the various other
sequentially selects the menu or function in the direction of rotation of the wheel Some are adapted to be determined is menu or function has been selected by pushing manipulation the wheel, the two-dimensional pointing device has been used from the conventional

are reduced compared to the work of visual load operation selection, simplification of the operation was attempted.

[0003] In addition

selection device information "described in JP-A-20
01-13978 JP,
another as a user interface in order to make a selection in the same way as above, for example, select information As the "method and the recording medium 択方
, to play the audio information associated with the item

select a plurality of audio information, corresponding to the selected item in sequence, select the desired What is provided to perform the decision operation at the time of the audio information associated with the item is re-produced
reduce the visual impact has been attempted more than the described above.

However

[0004] [SUMMARY OF THE INVENTION], in the rotary input device
of the former, the direction of movement of the poi
counter that indicates the position of the current selection / Forward
because that is limited to one-dimensional back, as shown in Figure 12 (a), the pointer k is freely movable
x, y in both dimensional pointing 2
, but the degree of Ru
is reduced somewhat by the device as compared with the selecting operation to watch the display screen, as shown in Figure 12
(b), the display item 1 Car
country due to the need to
visually track the movement of the pointer k, if that does not end in a row, to select the desired item
, visual impact, and the still large
There was a problem with the application to the device, such as vehicle navigation system.

[0007] In the apparatus selected
voice information using the information of the latter, the time for Ru
because relatively long recognized the voice information corresponding to the selected item,
operation is also time, Ku becomes inevitably long, there is a possibility that false positives applied to the device under vehicle audio information from other systems are mixed, there is a problem that it is difficult. In view of the above conventional problems
, vehicle-mounted device, such as in a car navigation system particularly, the present invention is easily visually without load
, the selection of a menu or function The aim of subjecting can provide a rotary input device.

the invention of claim 1
[Means for Solving the Problems]

が、前記表示画面の切り替えを伴って、前記項目間で選択を移動する際に、第４のトルク・パターンのトルクを前記ホイールに伝達するものとした。

【００１１】請求項６記載の発明は、前記第２、３または４のトルク・パターンが、前記ホイールの回転角に対してトルクが山型に変化するものであるものとした。

【００１２】請求項７記載の発明は、前記力発生手段が、前記ホイールに振動を伝達する振動発生手段であるものとした。

【００１３】請求項８記載の発明は、前記操作対象には、前記項目の選択範囲が設定され、前記振動発生手段は、選択範囲を越えて前記ホイールを操作した際に、前記ホイールに振動を伝達するものとした。

【００１４】請求項９記載の発明は、前記操作対象には、異なる機能または分類が設けられ、前記振動発生手段は、選択した項目の属性に応じて異なる振動を伝達するものとした。

【００１５】【発明の効果】請求項１記載の発明では、ホイールを操作し、表示部にて表示されている項目を順次に選択する際に、選択状況に応じて、ホイールに力を伝達するため、操作者は触覚により直感的に選択状況を理解することが可能となる。例えば行または列の切り替えあるいは項目の属する分類の変化などを認識することができる。従来は全面的に視覚に頼っていた選択状況の把握を、触覚でも部分的に可能となり、操作時の視覚負荷を低減することができる。また、音声により選択状況を報知する装置に比して、直感的かつ即座に、選択状況を認識できるから、確実かつ短時間に目的の項目を選択することができる。

【００１６】誇求項２の発明では、ホイールの操作方向である回転方向にトルクを伝達するようにしたので、操作者は選択操作の過程で、ホイール操作に必要な操作力の変化を知覚し、選択状況を認識できるため、特に有効に視覚負荷を低減することができる。

【００１７】請求項３の発明では、同一の機能または分類に属する項目間で選択を移動する場合と、機能または分類の切り替えを伴って項目間で選択を移動する場合とでは、トルク・パターンが異なるから、操作者は、トルク・パターンの変化により、機能または分類が切り替わったことを触覚で認識することができるため、表示画面を注視しなくても機能または分類の切り替えを確認でき、視覚負荷を低減することができる。

【００１８】請求項４の発明では、操作対象の項目が複数行または複数列で表示されている状態では、行または列が切り替わることを伴って項目間で選択を移動する場合、ほかと異なるトルク・パターンのトルクが用いられるから、操作者は、トルク・パターンの変化により、行または列が切り替わった選択を行ったことを触覚で認識することができるため、表示画面を注視しなくても行または列の切り替わりを確認でき、視覚負荷を低減することができる。

【００１９】請求項５の発明では、表示画面が切り替わることに伴って項目間で選択を移動する場合は、ほかと異なるトルク・パターンが用いられるから、操作者は、トルク・パターンの変化により、表示画面が切り替わったことを触覚で認識することができるため、表示画面を注視しなくても表示画面の切り替わりを確認でき、視覚負荷を低減することができる。

【００２０】請求項６の発明では、機能、分類または行、列あるいは表示画面が切り替わる選択を行う際に、ホイールに伝達されるトルクパターンは、ホイールの回転角に対してトルクが山型に変化するものが用いられるから、操作者は山を乗り越えるような感覚でホイールを操作する必要がある。このため、選択状況を直感的に理解できると共に、山型のトルク・パターンのため、境界に停留することなくスムーズに切り替えが行われ、操作性が向上する。

【００２１】請求項７の発明では、ホイールに伝達する力としては振動を用いるので、操作者はホイールに触れている限り任意の時点で、振動を知覚し、選択状況を認識できるため、選択操作の途中または完了時点の何れにおいても、有効に視覚負荷を低減することができる。

【００２２】請求項８の発明では、選択可能な範囲が限定されている場合は、選択範囲を超えてホイールが操作されると、ホイールに振動を伝達するから、操作者が選

[0006]

for
target operation that consists of multiple items have been displayed on the display unit By rotating the wheel to operate in a rotary input device to select the items sequentially
, force generating means is provided for transmitting a force to the wheel
described before, the host

to the ones which vary depending on the selected conditions the force transmitted to the wheel.

the said force generating means, the invention according to claim 2

[0007] is a
<dp n=0003> torque generating means for transmitting torque in the direction of rotation of said wheel I was with the thing.

The invention according to claim 3

[0008], classification is provided in different functions or subject to the operation, said torque generating means development, the same function or classification When you move the selection
between said items belonging, move between the items selected by said selection

Torr with the first clause of Torta pattern, the switching function or classification When was assumed that the torque transmitted to the wheel torque
second pattern.

eyes are visible above item is made to be operated multiple rows or columns on the display screen, the invention described in claim 4

[0009], wherein the means for generating torque, when moving the selection between the item accompanying the switching of the column I
was
shall be transmitted to said wheel torque of the torque · third pattern row or.

the torque generating means, when accompanied by a switching of the display screen, move the selected item choose between the invention described in claim 5

[0010] The fourth was assumed to be transmitted to said wheel
the torque of the torque patterns.

The invention according to claim 6

[0011],
torque pattern of 4, the torque on the mountain-rotation angle of the wheel relative to said second and third also I assume is intended to change.

the said force generating means, the invention described in claim 7

[0012], and the thing was
which is the vibration generating unit that transmits the vibration to the wheel.

the selection of the item is set, the invention described in claim 8

[0013],
is,
said vibration generating means, said wheel beyond the range selected for the operation When you operate, I shall transmit the vibration to the wheel
described before.

, the classification is provided subject to the operation or different function, the invention according to claim 9

[0014],
stage hand said vibration generation, depending on the attributes of the selected item I shall transmit the vibrations Ru
your deployment.

択可能な範囲を超えていることを触覚で認識でき、表示画面を注視して選択可能範囲の端点を確認する必要がなく、視覚負荷が低減される。

【００２３】請求項９の発明では、異なる機能または分類に属する項目が混在する操作対象から、項目を選択する際、項目の属性に応じてホイールに異なる振動を伝達するから、選択した項目の属性を触覚で認識することができ、表示画面を注視して選択した項目の属性を確認する必要がなく、視覚負荷が低減される。 <DP N=0004>

【００２４】【発明の実施の形態】次に、本発明の実施の形態を実施例により説明する。本実施例では、ホイールを用い、ホイールを回転操作することによって、表示画面上で表示されている選択メニュー一覧からメニューまたは機能などの項目を順次に選択するようになっている。図１は、ホイールの外観を示す図である。パネル４０からホイール４２が露出し、回転方向の操作とパネルに対する直角方向への押し込み操作が可能である。操作対象としては、図２に示すように、異なる機能が混在する選択メニューを用いる。ホイール４２を回転操作することによって、回転角に応じてポインタ３１が移動し、メニュー及び機能などの項目を選択する。その際、ポインタ３１の移動に応じて、ホイールにその回転方向にトルクを発生し、選択状況を触覚で認識できるようにしている。ポインタ３１の移動とトルクの関係の詳細は後述する。

【００２５】図３は、本実施例の構成を示す機能ブロック図である。回転または押し込み操作が可能なホイール４２に、ホイール駆動部４３とホイール位置検出部４４が接続され、ホイール駆動部４３はホイールの回転方向にトルクを発生し、ホイール位置検出部４４はホイール４２の回転角および押し込み操作を検出する。ホイール駆動部４３は例えば電動モータで、ホイール位置検出部４４は、例えばロータリ・エンコーダと押し込みスイッチで構成することができる。

【００２６】ホイール位置検出部４４とホイール駆動部４３は、それぞれホイール制御演算部４５に接続され、ホイール制御演算部４５では、ホイール位置検出部４４で検出した回転角情報および押し込み操作情報をディジタル化してホイールの操作情報として、通信部４６を介して操作・表示処理演算部４７に出力するとともに、ホイールの回転角に基づいてトルクパターンから、ホイール４２に発生するトルクを演算し、ホイール駆動部４３を制御する。

【００２７】操作・表示処理演算部４７は、ホイール制御演算部４５からのホイール操作情報から、ホイールの回転角情報を抽出し、それに基づいて、表示部４９で表示されている選択メニュー画面上でのポインタ位置を演算し、演算されたポインタ位置情報を表示部４９に出力して、ポインタを移動させる。また、ポインタがメニュー及び機能の項目に重なったときに、ホイールの押し込み情報が入ると、画面の更新情報を情報処理演算部４８に出力する。表示画面には、次頁または前頁のマークが設置され、ポインタがこれらのマークに重なったときには、頁の更新情報が情報処理演算部４８に出力される。

【００２８】情報処理演算部４８では、画面の更新情報または頁の更新情報に対応する情報処理を実施し、必要に応じて次の選択メニュー一覧情報を操作・表示処理演算部４７に出力し、表示部４９で表示される情報の更新を行う。メニュー一覧情報には、トルク・パターン情報が含まれ、このトルク・パターン情報は、通信部４６を介してホイール制御演算部４５に出力され、トルク・パターン情報の更新が行われる。

【００２９】上記、ホイール制御演算部４５は、Ａ／Ｄ変換回路、Ｄ／Ａ変換回路、ＣＰＵ、ＲＯＭなどで構成することができ、また、通信部４６はシリアル・インターフェース回路で構成することができるが、これに限ることではなく、同一機能をもつ他の装置でも構成することができる。

【００３０】次に、トルク・パターンについて説明する。本実施例では、図２に示すような電話帳リストを操作対象として説明する。電話帳リストは、図２に示すように、リストの先頭にリダイアル３５、電話番号入力３６という選択機能が設けられ、通常の電話帳に用いられている５０音順の選択機能と、異なる機能が混在しているものとなっている。表示上は、異なる機能に切り替わることを示す横スペーサ３２を配置し、視覚的に理解できるようになっている。

【００３１】また、本電話帳リストは、リスト項目が多

In the invention of claim 1

EFFECT OF THE INVENTION

[0015], when
to select item in order to work
manipulate the wheel, are displayed in the display unit,
Depending on the situation because
selected, force is transmitted to the wheel, and the operator can understand the situation
chosen by the sense of touch can be intuitive. You can recognize a change in the classification and the item belongs switch or e.g. a row or column. Can be even partially
touch sensation, the grasp of the situation that had relied on visual selection overall, are you traditional

it is possible to reduce the visual load during operation. In addition, compared to the device that
to inform the selection status by voice, and instantly intuitive, because Ru
can recognize the state of the selection, select the item you want to quickly and reliably can
.

The invention of claim 2

[0016] asked

boast, since the direction of rotation so as to transmit torque to the operating direction of the wheel is
, in the course of the selection operation, steering the wheel author In order to perceive a change in the operating force required to operate
can recognize the selected conditions, you will be able to reduce the visual impact
particularly effective.

If you want to move and choose between items that belong to the same function or class
minute, in the present

of claim 3, wherein

[0017], among items with a switching function or classification
In
and if you want to move the selection, torque pattern is different from the operator, by the change of the spectrum that tactile
network patterns, and Tsu
or classification function is switched it is possible to recognize in, you can come
can check the switching function or classification to reduce the visual impact without having to watch the display screen
.

The invention of claim 4

[0018], in a state where the item you want to work with are displayed in multiple columns or multiple lines
, the item with that row or column is switched
Since when Ru

If you want to move the selection between the torque of the torque that is different from other patterns are used, due to changes in the torque pattern, an operator
row or column order to be able to
recognized by tactile that you have made your selection has been switched, other
the row that you can check the switch of the column, to reduce the visual load without having to watch the display screen and can
.

In the present

of claim 5, wherein

[0019], if you want to move the selected item with that between Ru
switch the display screen, the torque pattern different from others is used
from, it is possible to recognize that tactile was

torque due to changes in the pattern, the display screen is switched, an operator display
not have to watch the display screen You may be able to check the switch on the screen to reduce the load
vision.

When you make a selection function, classification or row, column or display screen is switched, in the present

数のため、複数列、複数頁に亘って項目を配置している。表示上は、列の切り替わりを示す縦スペーサ３３、及び次頁が存在することを示す次頁マーク３４（前頁が存在する場合は前頁マーク）を配置して、視覚的に理解できるようになっている。

【００３２】項目の選択は、、ホイール４２を回転させることによって行う。ポインタ３１がホイール４２の回転角にしたがって点線で示す経路に沿って移動し、項目が順次に選択される。ポインタ３１が項目に重なった状態でホイール４２を押し込み操作を行うと、選択された項目が決定される。一方、ホイール４２を回転するときに、ホイール制御演算部４５では、ホイール４２の回転角に応じて、トルク・パターン情報から、選択状況に対応したトルクを演算するから、ホイール４２には、ポインタの移動に対応したトルクが伝達され、操作者が触覚で、ポインタの移動状況を認識することができ、視覚の負担が軽減される。

【００３３】次に、トルク・パターンを図４に示す発生トルク・ポテンシャルで説明する。発生トルク・ポテンシャルは、ホイールの回転角に対するトルクを積分したグラフであり、トルク・パターンを視覚的にイメージしやすいため説明に用いるが、実際に発生するトルクは、各回転角におけるグラフの傾きである。

【００３４】同一頁で、同一列かつ同一機能に属するリスト項目間でポインタを移動する際の発生トルク・ポテンシャルは、図４の区間５１に示すような発生トルク・ポテンシャルを割り当てる。例えば、ポインタを図２のリダイアル項目３５から番号入力項目３６へ移動する場合、リダイアル項目３５が選択されている状態では、図４のポイント５２のようなくぼみのある発生トルク・ポテンシャルを対応させる。 <DP N=0005>

【００３５】すなわち、ポイント５２周辺では、自然とポイント５２に引き寄せられるような感覚がホイールに発生するため、表示画面上のリダイアル項目３５を選択しやすいようになっている。ここで、ホイールを順方向に回転させ、ポイント５２のくぼみを乗り越えると発生トルク・ポテンシャルは水平になり、ホイールにトルクが発生しないスムーズな状態となる。

【００３６】そして、次の番号入力項目３６には、ポイント５３のくぼみを対応させることにより、ホイール回転角がポイント５３に接近すると、同様に引き寄せられるような感覚がホイールに発生し、ポイント５３すなわち番号入力項目３６を選択しやすい状態となる。

【００３７】このように、各リスト項目に対応するくぼみを配置し、配置したくぼみの間を水平に結ぶような発生トルク・ポテンシャルを割り当てることで、各リスト項目とホイールの操作感覚が一致し、容易に項目の選択、移動が可能となる。

【００３８】次に、異なる機能の切り替えを伴う選択操作の際の発生トルク・ポテンシャルは、図４の区間５４に示す発生トルク・ポテンシャルを割り当てる。例えば、図５の（ａ）に示すように、番号入力項目６１を選択した状態から、（ｂ）に示すように、リスト項目６２に移動する場合、番号入力項目６１とリスト項目６２には、ポイント５２と同様に、リスト項目箇所を示すくぼみのあるポテンシャル（ポイント５３、ポイント５６）を割り当てる。

【００３９】そして、ポイント５３とポイント５６の間に、山型のポテンシャル５５を割り当てる。すなわち、番号入力項目６１からリスト項目６２へポインタを移動させる際、ホイールには小山を乗り越えるような感覚が発生し、機能が切り替わったことを報知する。さらに、山型のポテンシャル５５は、表示画面上の横スペーサ６３に対応するため、視覚と触覚の対応が容易に付けられるようになっている。

【００４０】次に、列の切り替えを伴う選択操作の際の発生トルク・ポテンシャルは、図４の区間５７に示す発生トルク・ポテンシャルを割り当てる。例えば、図６の（ａ）に示すように、電話帳リスト１列目最下段のリスト項目７１を選択した状態から、図６の（ｂ）に示すように、電話帳リストの２列目最上段のリスト項目７２に移動する場合、リスト項目７１とリスト項目７２には、ポイント５２と同様、リスト項目箇所を示すくぼみのあるポテンシャル（ポイント５８、ポイント５９）を割り当てる。

【００４１】そして、ポインタ５８とポインタ５９の間に、山型のポテンシャル６０を割り当てる。すなわち、

of claim 6, wherein

[0020], the torque is transmitted to the
pattern wheel, the wheel
from what you want to change the type mountain torque
against rotation angle
times are used, it is necessary to operate the wheel
overcome the mountain feeling like an operator. For this
reason, it is possible to intuitively sense solution
selection situation, because of the torque pattern of the
mound, the switching is done smoothly without having to stop
to
boundary, the operation
I improved the.

Due to the use of vibration as a force to be transmitted to the
wheel
, at any time, in the present

of claim 7, wherein

[0021], unless the operator has a vibration perception
touch the wheel In order to, you can identify
recognize the state of the selection, you can can have
in any way or at the completion of the selection operation,
effectively reduce the visual load.

wheel is to operate above the selection, in the present

of claim 8, wherein

[0022], that can be selected when the range is limited
constant, the vibration in the wheel because transmission can
be recognized by tactile that an operation is beyond the range
that can be selected
selection, check the end points of the range can be selected
to watch the screen display the need

come, visual load is reduced.

from the operation target items belonging to the class
mixed-function or minutes, when Ru
, in the present

of claim 9, wherein

[0023], wheel depending on the attributes of items to select
an item because
transmitting vibrations different, I need Ru
verify the attributes of the item to be recognized in the haptic
attributes of the selected item can be
, were selected to watch the display screen without, visual
load is reduced. <dp n=0004>

Next, an embodiment of the Invention

[0024]

, described by way of example
implementing an embodiment of the present invention. By
using the wheel to rotate the host operating
wheel, in this embodiment, any items sequentially from the
list
such menu or function selection menu is displayed on the
display screen
It is now selected. 1 is a diagram showing the appearance of
wheel.
Hoi module 42 is exposed from the panel 40, the operation for
pushing in the direction perpendicular
panel operation and the direction of rotation is possible.
Is used in computing Meni
~Yu selection as shown in Figure 2, different functions are
mixed as the operation target. Te
By rotating the wheel 42 to manipulate the pointer 31 is
moved in accordance with the rotation angle, select an item,
such as a fine feature
及 menu. In that case, according to the movement of the
pointer 31
to
rotational torque in the direction of the wheel, we are able to
recognize the situation tactile selection. See below for details
of the relationship between movement and torque of poi
counter 31.

FIG.

3 is a block diagram showing the configuration
clock function of this embodiment.
42 to the wheel can be rotated or pressing operation, is
connected to the position detector 44
wheel driving unit 43 and the wheel, the wheel driving unit

リスト項目７１からリスト項目７２へ列を越えてポインタを移動させる際、ホイールには山を乗り越えるような感覚が発生し、列が切り替わったことを報知する。さらに、山型のポテンシャル６０は、表示画面上の縦スペーサ３３に対応しているため、視覚と触覚の対応が容易に付けられるようになっている。また、前記の機能切り替えを示す山型ポテンシャル５５と、列切り替えを示す山型ポテンシャル６０は、図４に示すように、ポテンシャルの大きさを変えることにより、両者の違いが把握できるようになっている。

【００４２】次に、頁の切り替えを伴う選択操作の際の発生トルク・ポテンシャルは、図４の区間５０１に示す発生トルク・ポテンシャルを割り当てる。例えば、図７の（ａ）に示すように、電話帳リスト１頁目最下段のリスト項目８１を選択した状態から、図７の（ｂ）に示すように、電話帳リストの２頁目最上段のリスト項目８２に移動する場合、リスト項目８１とリスト項目８２には、ポイント５２と同様、リスト項目箇所を示すくぼみのあるポテンシャル（ポイント５０２、ポイント５０３）を割り当てる。そして、ポイント５０２とポイント５０３の間に、山型のポテンシャル５０４を割り当てる。すなわち、リスト項目８１からリスト項目８２へ頁を越えてポインタを移動させる際、ホイールには山を乗り越えるような感覚が発生し、頁が切り替わったことを報知する。

【００４３】また、頁切り替えを示す山型ポテンシャル５０４は、図示のように、頂上部に突起を配置しているため、ポテンシャルの大きさが同程度でも、列切り替えを示す山型ポテンシャル６０と区別ができるようになっている。

【００４４】本実施例によれば、ホイールの操作方向である回転方向のトルク変化を利用して、図２に示すような異なる機能に属するメニューが混在し、複数列かつ複数頁からなる選択メニューの操作において、機能、列、頁の切り替わりを、ホイールによる選択操作の過程で触覚により知覚することができ、さらに機能、列、頁の区別も触覚で行うことができるため、表示画面を注視しなくても機能、列、頁の各々の切り替わりを直感的かつ即座に確認でき、視覚負荷を低減することができる。

【００４５】本実施例では、異なる山型ポテンシャルの区別をポテンシャルの大小、頂上部の突起の有無により表現しているが、ポテンシャルが山型である限り、その他の表現の組合せを採用してもよい。本実施例では、電話帳リストについて説明したが、操作対象としては、異なる機能、分類に属するメニューが混在しているもの、複数列、行から構成されているもの、または、複数頁から構成されているものなど、どのような選択メニューにも適用できる。

【００４６】なお、本実施例では、選択された項目を決定するために、ホイールの押し込み操作の代わりに独立した別のスイッチを設け、該スイッチ操作により決定操作を行う構成としてもよい。また、本実施例では、操作・表示処理演算部４７と情報処理演算部４８は、別の機能として説明したが、これらの機能を一つの装置で実現<DP N=0006>してもよい。

【００４７】また、前記ホイール制御演算部４５と操作・表示処理演算部４７との機能分担は、必ずしも本実施例の通りである必要はなく、ホイール制御演算部４５で行うものとした発生トルク量の演算は、操作・表示処理演算部４７で実施するような構成としてもよい。但し、この場合、発生トルク量をリアルタイムで操作・表示処理演算部４７からホイール制御演算部４５に出力する必要があるため、操作・表示処理演算部４７と通信部４６の間の通信は、高速にするのが好ましい。

【００４８】本実施例では、図４に示す区間５１で割り当てられるトルク・パターンは第１のトルクパターンを構成する。区間５４でのトルク・ポテンシャルは第２のトルク・パターンを構成する。区間５７でのトルク・ポテンシャルは、第３のトルク・パターンを構成する。区間５０１でのトルク・ポテンシャルは、第４のトルク・パターンを構成する。

【００４９】次に、第２の実施例を説明する。第１の実施例では、ホイールを回転させて、メニューを選択するときに、機能、行、列、頁に応じて、異なるポテンシャルのトルクを発生するようにしたので、操作時の感触で、選択された項目を触覚でも認識することができる。

【００５０】第２の実施例では、図８に示すように、第

43 generates a torque in the direction of rotation of the wheel

the, wheel position detector 44 detects the pressing operation and the angle of rotation of the wheel
42. For example an electric motor, the wheel drive unit 43 is

44 wheel position detection unit can be configured with the push switch
rotary encoder switch, for example.

calculating unit 45 is connected to the control wheel, respectively, in the control arithmetic unit 45
wheel,
43

wheel drive unit 44 and the position detection unit

[0026] wheel, wheel position detector 44
as operation information of the wheel, and outputs the operation and display processing operation unit 47 to via the communication unit 46 into digitizing
barrel pushing information and operation information detected by the rotation angle, from the torque pattern, calculating the torque generated in Hoi
Le 42, to control the 43
wheel drive unit based on the angle of rotation of the wheel ho.

from the operation information from the wheel of your computing unit 45
control wheel, to extract information
rotation angle of the wheel, on the basis of it,

47 operation and display processing operation section [0027], the display
The information on the display unit 49 outputs the computed position pointer
played the position of the pointer on the screen selection menu is shown in Table
section 49, has been computed, the pointer Move. Also, when the pointer is moved to the menu items and functions
ー, including information
only push the wheel is turned on, the output to the information processing arithmetic unit 48
screen updates to. On the display screen,
The updates page is output to the data processing operation unit 48 when the mark on the previous page or the next page is placed
, pointer is moved to these marks. in information processing calculating unit 48 [0028], to implement information processing corresponding to the updates page
or update information on the screen, the following information, depending on the selection menu list need performed
update of information to be output to the display processing unit 47 calculates played
operation and is displayed in the display unit 49.
Torque information includes the pattern is output to the control arithmetic unit 45 via wheel
the communication unit 46, a menu list information, the information pattern torque, the torque-path
turn information update is performed.

In addition, you can configure
conversion circuit A / D
, converter D / A, CPU, such as ROM,

above [0029], 45 wheel control arithmetic unit, a communication unit 46 It is possible to configure a serial interface circuit
ー face, not that
limited to this, and can also be configured in this other devices that have the same function.

[0030] Next,

, Ru
describes torque pattern. In this embodiment, operation will be described as the target phone book list
operation as shown in FIG. Select function 35 redial, 3
6 Enter the phone number that is provided at the beginning so I
shows, the list in Figure 2, the phonebook list,
usually used in the phone book What has become Ru
selection and are arranged in alphabetical order, different functions are mixed. Place the spacer 32 indicates that lateral switched to different functions, on the display, so that can understand visually.

[0031]

also, because of the number

１の実施例におけるトルクを発生するホイール駆動部４３の代わりにホイールに振動を伝達するホイール駆動部４３′を備える。そのほかは、ホイール制御演算部４５と操作・表示処理演算部４７の代わりにホイール制御演算部４５′と操作・表示処理演算部４７′を用いる。

【００５１】操作・表示処理演算部４７′は、ポインタが位置する項目の内容に応じて、振動パターンを決定し、ホイール制御演算部４５′は、操作・表示処理演算部４７′から受信した発生振動パターン情報とホイールの回転角情報から振動のＯＮ／ＯＦＦ周期を計算し、ホイール駆動部４３′に振動制御信号を出力する。

【００５２】ホイール駆動部４３′は、例えば非対称の振動子を連結した電動モータ、ホイール位置検出部４４は例えばホイール４２の回転に対して周期的に接点が開閉するマイクロ・スイッチで構成することができる。また、トルクを順方向／逆方向に高速に振動させることができれば、第１の実施例と同じように、電動モータを用いて、ホイール４２に振動を伝達させることも可能である。操作・表示処理演算部４７′はトルク・パターンではなく、発生振動パターンを出力すること以外は、第１の実施例における操作・表示処理演算部４７と同等の機能を有する。

【００５３】次に、本実施例における振動の発生方法を説明する。本実施例では、図９のようなメール受信リストを操作対象とする。本メール受信リストは、図９に示すように、開封済みシンボル１１２で視覚的に識別可能な開封済みメールと、未開封シンボル１１３で視覚的に識別可能な未開封メールとの２つの分類に属する選択メニューが混在している。

【００５４】開封済みメールと未開封メールの２つの分類を区別させるため、開封済みメールに対しては、振動無しを割り当て、未開封メールに対しては、図１０の（ａ）の振動パターンを割り当てる。すなわち、ホイール４２を操作してポインタ１１１が未開封メールを選択した時点から、ホイール４２が小刻みに３回振動して停止する。従って、この振動パターンの有無により選択したメールが開由済みか、未開封かを識別することができる。

【００５５】次に、図１１に示すように選択可能範開の端をポインタ１１１が選択している際に、さらにホイール４２を順方向に操作した場合、選択可能範囲を越えて操作したことを示すため、図１０の（ｂ）の振動パターンを割り当てる。すなわち、ホイール４２を選択可能範囲を越えて操作した時点から連続的に振動を発生し、一定時間経過後に停止する。従って、この振動パターンの有無により現在の操作が、選択可能範囲内か範囲外かを識別することができる。

【００５６】なお、図１０は、あくまでも理想的な振動パターンを図示しており、実際はホイール駆動部４３′の特性により、振動の立ち上がり、立ち下がりの波形は様々である。本実施例では、振動パターンとして、振動無し／３回振動／連続振動とし、各振動は同一周期・振幅のサイン波形としたが、ホイール駆動部４３′の特性、ホイール制御演算部４５′の制御方法により、パルス波形、三角波形、鋸波形、等の様々な波形を採用してもよいし、振動の周期や振幅を変化させて、振動パターンを作成してもよい。また、振動パターンの数・組合せも、識別可能な範囲で自由に設定してよい。

【００５７】また、本実施例では、メール受信リストについて説明したが、操作対象としては、異なる機能、分類に属するメニューが混在しているもの、または、選択可能範囲が限定されているものなどであればどのような選択メニューにも適用できる。

【００５８】本実施例によれば、図９、図１１に示すような異なる分類に属するメニューが混在し、選択可能範囲が限定されている選択メニューの操作において、ホイールにより選択を実施した際、選択可能範囲を越えて操作しているか否か、また選択可能範囲であれば、選択した項目の属性が何かを、振動パターンにより触覚で認識することができるため、表示画面を注視しなくても直感的かつ即座に選択結果を確認でき、視覚負荷を低減することができる。

【００５９】また、第１の実施例と同様に、ホイール制御演算部４５′と操作・表示処理演算部４７′との機能分担は、必ずしも本実施例の通りである必要はなく、ホイール制御演算部４５′で行うものとした発生振動のＯＮ／ＯＦＦ、周期の演算を操作・表示処理演算部４７′

, this phone book list, Ru
have placed items over multiple columns, multiple page many items to list. On the display, indicating the switching of vertical spacers 33 column, mark 34 on the next page and the next page to indicate that there is
(if the previous page exists
marked previous page) to place the are able to understand visually
.

[0032] The selection of items

, Ru
done by rotating the wheel 42. the pointer moves along the path indicated by the dotted line 31 in accordance with rotation angle of the wheel 42
times are selected sequentially
field. When you do push the wheel 42 in Thailand
like the pointer 31 is overlapped with item,
you selected is determined. On the other hand,
, in calculating unit 45 control wheel, depending on the angle of rotation of the wheel 42
, from torque pattern information, the response to the situation versus
Select to rotate the wheel 42 from the calculated torque, the torque corresponding to the movement of the point
printer is transmitted, the operator at
tactile, you will be able to recognize the status of movement of the pointer on the wheel 42, the visual
burden is reduced.

[0033] Next,

described in
torque generation potential shown in Figure 4 torque pattern. Graph is obtained by integrating the torque with respect to the rotation angle of the wheel, torque pots
Shall occur, we are used to describe the image for easy visually torque pattern, actually torque generated is the slope of the graph at each rotation angle
.

Grupotel
Nsharu torque occurs when

[0034] In the same page, move the pointer between Li
list item belonging to the same column and the same feature is shown in section 51 of Figure 4 ·
assign torque generation potential like. For example, in a state where the case
If the number of input fields F 36 moves from item 35 of Figure 2
redial pointer redial item 35 is selected, the point 52 of FIG. 4 point to the corresponding torque occurs with depression Tensharu like. <dp n=0005>

[0035] In other words, in order to sense, such as those drawn to point 52

naturally occurs in the wheel, select around 52 points, I'm supposed to make it easier to.
Torque generation potential here is horizontal, rotate the wheel forward to
, and overcome the depression of point 52, it is in a state that does not generate a smooth
the torque to the wheel.

[0036] and, by dint of points corresponding to the client 53 times
wheel rotation angle approaches the point 53, to 36 the next number input field, as well as draw a state of feeling, such as occurs in the Ru
wheel is easy to select the input item number 36 of course it 's Su
53 points.

[0037] In this way, you can assign a torque potential from raw

placed himself trough corresponding to each list item, such as a horizontal tie between the indentations were placed in the sense of moving the wheel each list item and
match, selected
selection of items, can be easily moved.

[0038] Next,

, torque generation potential at the time of his selection operation with switching of different functions, assign a torque generation potential 54
shown in section in Figure 4. If
example, as shown in Figure 5 (a), the state of being selected

<DP N=0007>で実施するような構成としてもよい。但し、この場合、
発生振動のＯＮ／ＯＦＦ、周期をリアルタイムで操作・表示処理演算部４７'からホイール制御演算部４５'に出力する必要があるため、操作・表示処理演算部４７'と通信部４６の間の通信は、高速にするのが好ましい。

from
select the number input field 61, as shown in (b), the move to list items 62
If you want to, as well
, and point 52, with only potential
trough indicate where the list item (point 53, point 56) I assign.

[0039] and, in
between 53 points and 56 points, assign a potential 55 of the mound. That is, when you move the pointer to
Items 61 to 62 list items from input number
, the wheel is notified that overcome feeling like a hill occurs
, function is switched. Furthermore, in order to correspond to the 6
3 next to spacer on the display screen 55 of the mound potential is such
Ri corresponding visual and tactile easily attached.

[0040] Next,

,
torque generation potential during the selection operation involving the switching of a column, assign a torque potential from raw
section 57 shown in Figure 4. For example, as shown in (a) of Figure 6, from the state in which the select list item 71 first column bottom port of the phone book list, shown in Figure 6 (b) <
If you want to move to the top 72 list items in the second column so
, the phone book list, as well as 71 and 72 in the list item list item, and
point 52, where the list item
hit percentage (point 58, point 59) the potential of the recess there
Ru show.

[0041] and

,
between 59 to 58 Pointers and Pointer, assign a potential 60 of the mound. That is, when you move the pointer over the column
data from 71 to 72 list items
list item, such as feeling
overcome the mountain occurs, the column wheel is switched I will notify that.
In addition, because it corresponds to the space
vertical size of the display screen 33, 60 potential of the mound, the response of the visual and tactile so easily attached
have. As shown in Figure 4, and potential angled 55 showing an example of the function switch
potential
mountain type 60 indicates the column switch, the size of the Potensha
Le By varying, so that Ri
difference between the two can be understood.

[0042] Next,

,
torque generation potential during the selection operation involving the switching of the page, assign a torque generation potential
section 501 shown in Figure 4. For example, as shown in Figure 7
(a), the state of the selected item 81 re-strike the bottom first page phone book list, shown in Figure 7 (b)
As you can, if you want to move to the top of the list items 82
the second page of the phone book list, as well as
, and point 52, where the list item to list items 81 and 82 list items assign (point 502, 50
3 points) the potential of
indicate depression. And while
503 points and 502 points, 504 Ru
potential allocation of the mound. That is, when you move the pointer over the page
Items 81 to 82 list items from the list and wheel <Ri beyond that feeling like riding a mountain
occurs, the page is switched informing
.

[0043] In addition

, because that
As shown, the projections are arranged on the top, potential 504 mountain type that indicates the page switching, even comparable to the size of the potential, it has
will be able to distinguish potential mountain type 60 showing

the
column switching.

According to an embodiment of the present invention [0044]

, menu belonging to the ability to use the change in torque in the direction of rotation in the direction of operation of the wheel there
different
such as shown in Figure 2 mixed be perceived by the sense of touch in the course of the operation
wheel selection, in the operation of the selection menu that consists of multiple columns and multiple
page number, the switch function, column, page
because you can be able to be done in a different tactile district also further functions, column, page, intuitive function of each switch also comes
Do not pay attention to the display screen, column, page We can seat can be confirmed immediately
and to reduce the visual load.

[0045] In this embodiment, but are represented by the presence or absence
magnitude of the potential, of the projection of the top portion of the distinction
different mountain-type potential, as long as the potential is a mountain- You may employ a combination of other expressions that
. In this embodiment, the description has been given electric Phonebook list, those features that
different menu belonging to the classification are mixed, multi-column
, as the operation target, the line
which can be applied are composed of, or such as those which are configured from multiple page or
, what selection menu.

[0046] In addition

, to the constant
determine the selected item, another switch provided with independent
instead of pressing operation of the wheel, in this embodiment, the switch operation may be configured to perform the work
determined by the operation. Further, in this embodiment, the information processing calculating unit 48 and the display processing operation unit 47
· The operation has been described as a separate unit function, implemented in a single device I may be <dp n=0006>.

[0047] In addition

need not be exactly as in the example embodiment of the present invention necessarily
, division of functions and calculation display processing section 47
· wheel control arithmetic operation unit 45, wherein the control wheel The calculation of the amount of the generated torque with
shall be made in the calculation unit 45 may be configured as implemented in the calculating unit 47
operation and display processing. However, in this case
,
needed because there is need to control arithmetic unit 45 outputs the wheel from the calculation unit 47
management operation and display processing in real time the amount of torque generated, the processing operation and display 46
communication between the communication unit and the arithmetic unit 47, it is preferable to speed.

[0048] In this embodiment, the torque pattern assigned assigned in section 51 shown in Figure 4 consists of a torque first pattern. Torque potential of section 54 constitutes a second pattern
torque. Po torque
Tensharu of section 57 constitutes a third torque pattern. Torque potential of between 501
district constitutes a fourth torque ·
pattern.

[0049]

then, the second embodiment will be described. In the first real
Example, the torque of the Potensha

Le that when you rotate the wheel to select the menu, depending on function, row, column, page, different to occur because, in

feel of operation, I can recognize even tactile the selected item.

As shown in Figure 8 [0050] In an embodiment

second wheel vibration instead of 4
3 wheel driving unit for generating a torque in the first embodiment
1 equipped
43 'wheel drive unit to transmit. In addition to this, use the 'operation and display processing operation unit 47' and the calculation unit 45 played
control wheel in place of the operation and display processing operation unit 47 and the control arithmetic unit 45
wheel.

'in accordance with the contents of the item you want to position the pointer
,
to determine the vibration pattern, and wheel control arithmetic unit 45'

47 operation and display processing operation section [0051], the operation · 'to calculate the cycle ON / OFF of vibrations from the angle of rotation of the wheel
information and information received from the vibration pattern generation,
wheel driving section 43 (e)' operation
display processing section 47 to Vibration control signal is output.

an electric motor coupled to a vibrator
asymmetric,

43 'wheel driving unit [0052], 44
wheel contact position detection unit periodically with respect to the rotation of the wheel 42, for example can be configured in a micro-switch that is opened
closed. It vibrated at high speed forward / reverse direction was
addition, the torque is able to
, in the same way as the first embodiment, but
for an electric motor, the wheel 42 A Ru
also possible to transmit the vibrations.
Rather than a torque pattern 47 'operation and display processing operation unit, except that the vibration pattern generation output is equivalent to the operation and display processing operation unit 47 in the first embodiment 1

having the ability to machine.

[0053] Next,

describes a method for generating a vibration
in the present embodiment. In this embodiment, the operation target and the received mail list, such as remote
9. As shown in Figure
shown in Figure 9, e-mail and saved such
identifiable received this email list is, New menu selection belonging to two categories can be identified with the mail unopened are mixed.

In order to distinguish between the two kinds of minute

unopened mail and e-mail saved [0054], assign
without vibration, the mail is saved, the mail unopened assigns a vibration pattern
(a) of Figure 10. That is, from the time that pointer 111 was select the mail unopened to operate the Le Hoi
42,
stop stop wheel 42 is vibrated three times little by little.
Therefore, I can email Ru

was selected by the presence or absence of this vibration pattern is already open reason, to identify whether unopened.

[0055]

then, when the pointer 111 is to select the end of the open range
can be selected as shown in Figure 11, was operated in the forward direction
Le Hoi further 42 to indicate that the case was beyond the range of operation can be selected
assigns a vibration pattern
emissions Figure 10 (b). In other words, the vibrations occur continuously from the time of operation beyond the range
range wheel 42 can be selected to stop after a certain time one. Therefore, we can be the current operation,
identify whether within or outside the scope of the pattern can be selected according to the presence or absence
this vibration.

[0056] It should be noted that, in Figure 10, we have shown a pattern
ideal vibration only, due to the characteristics of the 43 ' wheel drive unit, the rise of the vibration, the actual waveform of the falling There are various
. A vibration pattern, and no continuous vibration and vibration
vibration / times / 3, in this embodiment, each vibration sine waveform width was
Hu same period, especially 43 'wheel drive unit The control method of
, 45 'wheel control arithmetic unit, may be adopted various waveforms pulse waveforms
graphics, triangular waveform, sawtooth waveform, such as, the vibration by varying the amplitude and period, you may create a putter
vibration emissions. In addition, the number of vibration patterns
combination, may be set freely in a range that can be identified.

[0057] In addition

, in the present embodiment has been described with to your e-mail received, as the operation target, those different functions, menus that belong to the class minutes are mixed, or can be applied to any long selection menu such as those selected
range is limited.

According to an embodiment of the present invention [0058]

selection menu menu belonging to different categories such shown in Figure 9, Figure 11 is a mixture of
range selectable range is limited If the selectable range, order to be able to recognize the tactile
by vibration pattern, what the attributes of the item was, you can see the results immediately and select a
intuition without watching the display screen, visual load I can

to reduce.

[0059] In addition

, similarly to the first embodiment,
sharing feature with the 'operation and display processing operation unit 47' and the control arithmetic unit 45
control wheel is always present need not be exactly as in the example 'operation and display processing operation section 47 O
N / OFF of vibrations that occur shall be made in the calculation of the period of' calculating section 45 (e) control wheel
<such a configuration may be carried out at <dp n=0007>.
However, in this case, it is necessary to output
the 'wheel control arithmetic unit 45 from the' calculation unit 47 operate in real-time processing ·
display ON / OFF of the vibration generator
, the period communication between the communication unit 46, for fast and 47 '
operation and display processing operation unit is preferred.

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SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
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Sir:

Pursuant to 37 C.F.R. §§ 1.97 and 1.98, applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I.. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the PTO/SB/08 forms attached hereto.

II. COPIES (check at least one box)

a. ☐ This application was filed before June 30, 2003. Accordingly, submitted herewith is a legible copy of (i) each U.S. and foreign patent; (ii) each publication or that portion which caused it to be listed; and (iii) all other information or that portion which caused it to be listed.

b. ☒ This application was filed on or after June 30, 2003. Accordingly, copies of cited U.S. patents and patent application publications therefore are not included. Copies of foreign patent documents and non-patent literature are included.

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An English language version of the search report or action that indicates the degree of relevance found by the foreign office is attached, thereby satisfying the requirement for a concise explanation. See MPEP 609(III)(A)(3).

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The following additional information is provided for the Examiner's consideration.

FEES

IV. ☒ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(b):
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a. ☐ within three months of the filing date of a national application (37 C.F.R. § 1.97(b)(1)). No fee or statement is required. *(This section is not to be used with RCE's.)*

b. ☐ within three months of the date of entry of the national stage as set forth in § 1.491 in an international application (37 C.F.R. § 1.97(b)(2)). No fee or statement is required.

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In the event that a first Office Action on the merits has been issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) below, or, if no statement has been made, charge our deposit account in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

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before the mailing date of a Final Office Action under 37 C.F.R. § 1.113 (See 37 C.F.R. § 1.97(c)(1)) or before the mailing date of a Notice of Allowance under 37 C.F.R. § 1.311 (See 37 C.F.R. § 1.97(c)(2)).

a. ☐ No statement; therefore, a fee in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

b. ☐ See the statement below. No fee is required.

VI. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(d)
after the period specified in 37 C.F.R. 1.97(c) but before payment of the issue fee; see statement and payment of fees below.

VII. STATEMENT UNDER 37 C.F.R. § 1.97(e) (check only one box)
The undersigned hereby states that

a. ☐ each item of information contained in the IDS was first cited in any communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS;

b. ☐ no item of information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS.

c. ☐ Some of the items of information were cited in a communication from a foreign Patent Office. As to this information, the undersigned states that each item of information contained in the IDS was first cited in a communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS. As to the remaining information, the undersigned hereby states that no item of this remaining information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application and, to the best of my knowledge after making reasonable inquiry, was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

VIII. ☐ PATENT TERM ADJUSTMENT

Each item of information contained in this Information Disclosure Statement was first cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of this Information Disclosure Statement. 37 C.F.R. § 1.704(d).

IX. PAYMENT OF FEES (check one box)

☐ Payment by credit card Form PTO-2038 in the amount of $180 required by 37 C.F.R. § 1.17(p) is enclosed for the above-identified fee.

☐ Please charge Deposit Account No. 20-1430 in the amount required by 37 C.F.R. § 1.17(p) for the above-indicated fee. A triplicate copy of this paper is attached.

☒ No fee is required.

If the Examiner has any questions concerning this IDS, he/she is requested to contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the PTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 20-1430.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 20-1430 for any additional fees required under 37 C.F.R. § 1.16 or under § 1.17.

Respectfully submitted,

Date: 2/11/2016

By: /Michael T. Morlock/
Michael T. Morlock (Reg. No. 62,245)

Attachment(s):
☒ PTO/SB/08
☒ Documents
☐ Fee
☐ Other

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	11/965,046
Filing Date	December 27, 2007
First Named Inventor	Michael D. Levin
Art Unit	2623
Examiner Name	Zubajlo, Jennifer L.
Attorney Docket Number	IMM253 (051851/0339922)

U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number - Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] - Number[4] - Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1.	JP 2003-153354	05-23-2003	Alps Electric Co. Ltd.		X
	2.	JP 2006-163206	06-22-2006	NTT Docomo Inc.		X
	3.	WO 2006/020304	02-23-2006	Apple Computer Inc.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	4.	Japanese Patent Office, Notice of Reasons for Rejection, Application No. JP 2015-087121 dated February 16, 2016.	

Examiner Signature		Date Considered	

Espacenet

Bibliographic data: JP2003153354 (A) — 2003-05-23

HAPTIC INPUTTING APPARATUS

Inventor(s): KOBAYASHI AYUMI ± (KOBAYASHI AYUMI)

Applicant(s): ALPS ELECTRIC CO LTD ± (ALPS ELECTRIC CO LTD)

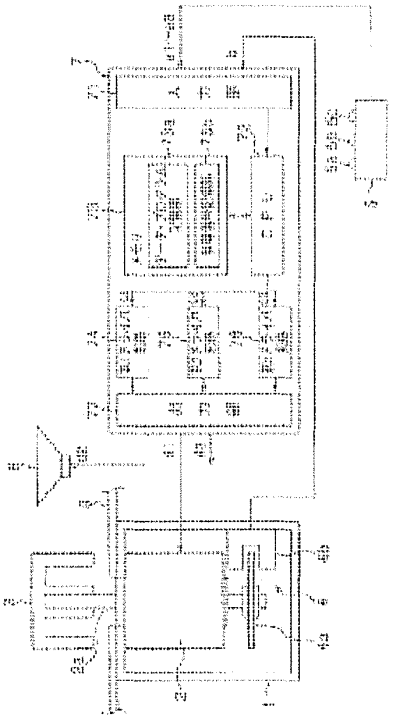
Classification: - **international:** ***G05G5/03; H04Q9/00;*** (IPC1-7): G05G5/03; H04Q9/00
- **cooperative:**

Application number: JP20010343510 20011108

Priority number(s): JP20010343510 20011108

Abstract of JP2003153354 (A)

PROBLEM TO BE SOLVED: To provide a haptic inputting apparatus whereby a good operational feeling can be obtained even under the severe condition hard to perceive the touch feeling of a knob, and in addition to this, colorful operational feelings can be obtained. SOLUTION: The haptic inputting apparatus is formed out of a housing 1; an actuator 2 provided in the housing 1; a rotary knob 3 fastened to one end of a driving shaft 2a; a sensing means 4 provided on the other-end side of the driving shaft 2a; a switch 5; a speaker 6; and a controlling means 7 for controlling the whole of the system of the haptic inputting apparatus. There are stored in a memory 73 provided in the controlling means 7 a controlling signal c1 of the actuator 2; a controlling signal c2 of the speaker 6; and a controlling signal c3 of a selected electric appliance mounted on a vehicle. When an operator operates the rotary knob 3, the responsive controlling signals c1, c2 to a sensing signal (b) are so read out from the memory 73 as to give to the operator the operational feeling comprising the combination of the external force applied to the rotary knob 3 with the sound generated from the speaker 6.



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Ｇ０５Ｇ　5/03		Ｇ０５Ｇ　5/03	Ｂ	５Ｋ０４８

審査請求　未請求　請求項の数６　ＯＬ　（全 10 頁）

(21)出願番号　特願2001－343510(P2001－343510)

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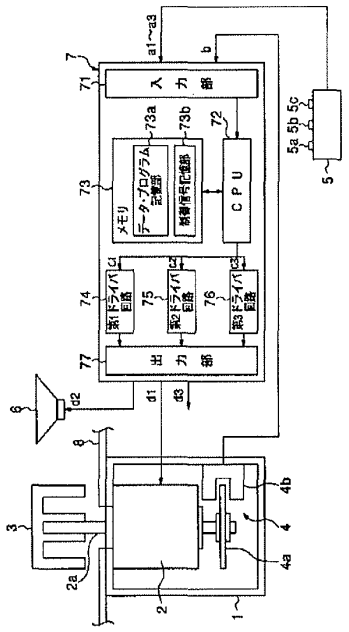
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(74)代理人　100078134
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BA32 BA34 BA51 CC71 CD31
CE01 DA02 DA52 DA61 EA31
5K048 AA04 BA42 DA02 EB02 EB10
FB11 FC01 HA01

(54)【発明の名称】　ハプティック入力装置

(57)【要約】
【課題】　ノブの感触を感得しにくい過酷な条件下においても良好な操作フィーリングを得ることができ、かつ多彩な操作フィーリングを得ることができるハプティック入力装置を提供する。
【解決手段】　筐体１と、当該筐体１内に設置されたアクチュエータ２と、駆動軸２ａの一端に固着されたロータリノブ３と、駆動軸２ａの他端側に設けられた検知手段４と、スイッチ５と、スピーカ６と、システム全体を制御する制御手段７とからハプティック入力装置を構成する。制御手段７に備えられたメモリ７３に、アクチュエータ２の制御信号ｃ１とスピーカ６の制御信号ｃ２及び選択された車載電気機器の制御信号ｃ３とを記憶する。ロータリノブ３が操作されたとき、検知信号ｂに応じた制御信号ｃ１，ｃ２をメモリ７３から読み出し、ロータリノブ３に加えられる外力とスピーカ６より発生される音の組合せからなる操作フィーリングを操作者に与える。



1

【特許請求の範囲】

【請求項１】　操作者が手動で操作するノブと、前記ノブの操作状態を検知する検知手段と、前記ノブに外力を与えるアクチュエータと、可聴音を発生するスピーカと、前記検知手段より出力される検知信号に基づいて前記アクチュエータ及びスピーカの駆動を制御する制御手段とを有し、前記制御手段には、前記検知信号に応じた前記アクチュエータの制御信号及び前記検知信号に応じた前記スピーカの制御信号が記憶されたメモリを備え、前記制御手段は、前記ノブが操作されたとき、前記検知信号に応じたアクチュエータの制御信号及びスピーカの制御信号を前記メモリから読み出して前記アクチュエータの駆動信号及び前記スピーカの駆動信号を生成し、前記アクチュエータより与えられる外力及び前記スピーカより発生される可聴音の組合せよりなる前記ノブの操作フィーリングを操作者に与えることを特徴とするハプティック入力装置。

【請求項２】　前記メモリに、前記検知信号に応じた前記アクチュエータの制御信号及び前記検知信号に応じた前記スピーカの制御信号をそれぞれ複数種別ずつ記憶すると共に、前記制御手段に、前記メモリより読み出される前記アクチュエータの制御信号及び前記スピーカの制御信号の組合せを切り換えるスイッチを備えたことを特徴とする請求項１に記載のハプティック入力装置。

【請求項３】　前記メモリに、前記スピーカの制御信号として、操作者に正常な前記ノブの操作感を与える第１制御信号と、操作者に異常な前記ノブの操作感を与える第２制御信号とを記憶すると共に、前記制御手段に、前記ノブが不正操作されたか否かを判定する不正操作判定部を備え、前記不正操作判定部にて前記ノブが不正操作されたと判定された場合には前記メモリから第２制御信号を読み出し、前記不正操作判定部にて前記ノブが不正操作されていないと判定された場合には前記メモリから第１制御信号を読み出すことを特徴とする請求項１又は請求項２に記載のハプティック入力装置。

【請求項４】　前記メモリに、前記アクチュエータの制御信号として、前記ノブを一定方向に一定量操作するごとに前記ノブにクリック感触を与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記クリック感触の発生タイミングごとに音質が異なる可聴音を間歇的に発生する制御信号を記憶したことを特徴とする請求項１に記載のハプティック入力装置。

【請求項５】　前記メモリに、前記アクチュエータの制御信号として、前記ノブの操作に一定感触の微振動を与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記ノブの操作方向に応じて音質が異なる可聴音を連続的に発生する制御信号を記憶したことを特徴とする請求項１に記載のハプティック入力装置。

【請求項６】　前記メモリに、前記アクチュエータの制御信号として、前記ノブの操作にセンター復帰力と一定感触の微振動とセンター位置からの操作量に応じた抵抗感とを与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記ノブがセンター位置に復帰したタイミングで可聴音を発生する制御信号を記憶したことを特徴とする請求項１に記載のハプティック入力装置。

2

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、フォースフィードバック機能付きのハプティック入力装置に係り、特に、操作者が手動で操作するノブの操作感触の改善手段に関する。

【０００２】

【従来の技術】従来より、入力手段としてのノブの操作フィーリングを良好にしてノブの操作を確実なものにするため、ノブにその操作量や操作方向等の操作状態に応じた抵抗感や推力を付与するフォースフィードバック機能付きのハプティック入力装置が知られている。

【０００３】図９に、従来より知られているこの種のハプティック入力装置の一例を示す。本例のハプティック入力装置は、ロータリノブ１０１と、当該ロータリノブ１の回転量及び回転方向を検知する検知手段１０２と、ロータリノブ１０１に外力を負荷するアクチュエータ１０３と、検知手段１０２から出力される検知信号ａを取り込んでアクチュエータ１０３の制御信号ｃを生成する制御部１０４と、制御部１０４から出力された制御信号ｃをＤ／Ａ変換するＤ／Ａ変換器１０５と、Ｄ／Ａ変換器１０５によりアナログ信号に変換された制御信号ｃを増幅してアクチュエータ１０３の駆動電力を得る信号増幅器１０６とから構成されている。制御部１０４は、ＣＰＵ１０４ａとメモリ１０４ｂとから構成されており、メモリ１０４ｂには、検知信号ａに応じた制御信号ｃがテーブルの形で記憶されている。ＣＰＵ１０４ａは、検知手段１０２からの検知信号ａを取り込み、取り込まれた検知信号ａに応じた制御信号ｃをメモリ１０４ｂから読み出して、Ｄ／Ａ変換器１０５に出力する。

【０００４】これにより、アクチュエータ１０３が駆動され、ロータリノブ１０１にその操作量及び操作方向に応じた外力をフィードバックを作用することができるので、本例のハプティック入力装置は、ロータリノブ１０１の操作フィーリングが良好で、ロータリノブ１０１の操作を確実なものにすることができる。

【０００５】この種のハプティック入力装置は、例えばゲーム機の入力装置や、自動車におけるバイワイヤ方式のギアシフト装置、それに車載された各種の電気機器、例えば、エアコン、ラジオ、テレビ、ＣＤプレーヤ、ナビゲーションシステム等の機能調整装置として適用される。

【０００６】ギアシフト装置として適用する場合、ハプティック入力装置に備えられたフォースフィードバック機能は、シフトレバーのレンジ切替にクリック感触を与

えたり、例えばＰ（パーキング）レンジからＲ（リバース）レンジ、Ｄ（ドライブ）レンジから２ｎｄ（セカンド）レンジなど、特定レンジから他の特定レンジへのシフトレバーの不正な操作を禁止するロック手段などとして利用される。また、車載電気機器の機能調整装置として利用する場合、ハプティック入力装置に備えられたフォースフィードバック機能は、ロータリノブ１０１に適度な抵抗感を付与して機能の微調整を容易にしたり、ロータリノブ１０１に適度な推力を付与してロータリノブ１０１の操作を軽快にするのに利用される。

【０００７】なお、前記においては、ロータリノブ１０１を備えたハプティック入力装置を例にとって説明したが、ロータリノブ１０１に代えて、２次元方向に揺動可能なジョイスティック形のノブを備えたハプティック入力装置や、一定の面内で旋回するレバー形のノブを備えたハプティック入力装置も従来より知られている。

【０００８】

【発明が解決しようとする課題】しかるに、従来より知られているフォースフィードバック機能付きのハプティック入力装置は、ノブ１０１に作用するアクチュエータ１０３からの外力のみを操作者にフィードバックするので、例えば自動車が未舗装路を走行中の場合のように車体の振動が大きい場合には、ノブ１０１に作用する外力を操作者が感得しにくく、所望の機器の選択や選択された機器の機能調整を迅速かつ確実に行うことが難しくなるという不都合がある。

【０００９】また、ノブ１０１に様々なパターンの外力をアクチュエータ１０３より与えると、操作者はそのパターンに応じた認知が可能になるが、人間の認知という広義な観点で考えると、外力のみの認知にある程度の制限があることは前述の未舗装路の例からも明らかであり、外力のみによっては、操作者が識別容易な操作フィーリングを多様に作り出すことが難しいという不都合がある。

【００１０】本発明は、かかる従来技術の不備を解消するためになされたものであって、その課題とするところは、ノブの感触を感得しにくい過酷な条件下においても良好な操作フィーリングを得ることができ、かつ、より多様な操作フィーリングを得ることができるハプティック入力装置を提供することにある。

【００１１】

【課題を解決するための手段】本発明は、前記の課題を解決するため、第１に、操作者が手動で操作するノブと、前記ノブの操作状態を検知する検知手段と、前記ノブに外力を与えるアクチュエータと、可聴音を発生するスピーカと、前記検知手段より出力される検知信号に基づいて前記アクチュエータ及びスピーカの駆動を制御する制御手段とを有し、前記制御手段には、前記検知信号に応じた前記アクチュエータの制御信号及び前記検知信号に応じた前記スピーカの制御信号が記憶されたメモリを備え、前記制御手段は、前記ノブが操作されたとき、前記検知信号に応じたアクチュエータの制御信号及びスピーカの制御信号を前記メモリから読み出して前記アクチュエータの駆動信号及び前記スピーカの駆動信号を生成し、前記アクチュエータより与えられる外力及び前記スピーカより発生される可聴音の組合せよりなる前記ノブの操作フィーリングを操作者に与えるという構成にした。

【００１２】このように、制御手段に備えられたメモリにアクチュエータの制御信号とスピーカの制御信号とを記憶しておき、ノブが操作されたときに、制御手段が当該メモリより読み出された制御信号に基づいてアクチュエータの駆動信号及びスピーカの駆動信号を生成し、操作者にアクチュエータより与えられる外力及びスピーカより発生される可聴音の組合せに応じたノブの操作フィーリングを与えるという構成すると、操作者はノブに加えれたアクチュエータの外力及びスピーカから発せられる可聴音の双方によってノブの操作状態を知ることができるので、例えば未舗装路を走行中の場合のように車体の振動が大きい場合にもノブの操作フィーリングを正確に感得しやすく、所望の機器の選択や選択された機器の機能調整を迅速かつ確実に行うことができる。また、アクチュエータより与えられる外力とスピーカより発生される可聴音との組合せによって多種多様なノブの操作フィーリングを作り出すことができるので、操作者が識別可能な操作フィーリングの種類を増やすことができ、ハプティック入力装置の多機能化及び多用途化を図ることができる。

【００１３】本発明は、前記の課題を解決するため、第２に、前記メモリに、前記検知信号に応じた前記アクチュエータの制御信号及び前記検知信号に応じた前記スピーカの制御信号をそれぞれ複数種別ずつ記憶すると共に、前記制御手段に、前記メモリより読み出される前記アクチュエータの制御信号及び前記スピーカの制御信号の組合せを切り換えるスイッチを備えるという構成にした。

【００１４】このように、アクチュエータの制御信号及びスピーカの制御信号をそれぞれ複数種別ずつメモリに記憶しておき、制御手段に備えられたスイッチを操作することによってメモリより読み出されるアクチュエータの制御信号及びスピーカの制御信号の組合せを切り換えるようにすると、同一のノブを同一の方向に操作した場合にも、ノブに異なる操作フィーリングを付与することができるので、ノブの操作に種々の機能をもたせることができ、ハプティック入力装置の多機能化及び多用途化を図ることができる。また、スピーカの制御信号として、例えば重厚で操作者に高級感をイメージさせる音質の制御信号及び軽快で操作者にスポーティ感をイメージさせる音質の制御信号などの音質が異なる複数種別の制御信号をメモリに記憶しておくことによって、１つのハ

プティック入力装置を車種や車格が異なる多種の自動車に適用することが可能になるので、量産効果によるハプティック入力装置の低コスト化を図ることもできる。

【００１５】本発明は、前記の課題を解決するため、第３に、前記メモリに、前記スピーカの制御信号として、操作者に正常な前記ノブの操作感を与える第１制御信号と、操作者に異常な前記ノブの操作感を与える第２制御信号とを記憶すると共に、前記制御手段に、前記ノブが不正操作されたか否かを判定する不正操作判定部を備え、前記不正操作判定部にて前記ノブが不正操作されたと判定された場合には前記メモリから第２制御信号を読み出し、前記不正操作判定部にて前記ノブが不正操作されていないと判定された場合には前記メモリから第１制御信号を読み出すという構成にした。

【００１６】このように、制御手段にノブが不正操作されたか否かを判定する不正操作判定部を備え、当該不正操作判定部にてノブが不正操作されたと判定された場合に、メモリより操作者に異常な操作感を与える第２制御信号を読み出してスピーカを駆動するようにすると、例えば走行中におけるカーナビゲーションシステムの目的地設定など、安全上禁止されている操作を誤って行った場合に、不正操作判定部がノブに不正操作が行われたことを自動的に判定し、メモリから第２制御信号を読み出すことによって操作者に不正な操作が行われたことを音で報知することができるので、当該ハプティック入力装置が適用される機器の不正操作を防止することができ、安全性に優れる。また、ノブが予め定められた可動範囲外に操作されようとしたときにも、不正操作判定部の判定内容にしたがってメモリから第２制御信号を読み出すことによって操作者に不正な操作であることを音で報知することができるので、第１信号のみを場合に比較してより一層の認知性の向上が達成でき、その結果、より確実にノブの不正操作を防止することができて、ハプティック入力装置の信頼性を高めることができる。

【００１７】本発明は、前記の課題を解決するため、第４に、前記メモリに、前記アクチュエータの制御信号として、前記ノブを一定方向に一定量操作するごとに前記ノブにクリック感触を与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記クリック感触の発生タイミングごとに音質が異なる可聴音を間歇的に発生する制御信号を記憶するという構成にした。

【００１８】このように、アクチュエータの制御信号としてノブにクリック感触を与える制御信号を記憶すると共に、スピーカの制御信号としてクリック感触の発生タイミングごとに音質が異なる可聴音を間歇的に発生する制御信号を記憶すると、スピーカから発する音を聞くことによって、ノブの操作方向及び操作量をブラインドタッチで知ることができるので、例えばエアコンの温度調整のようにアクチュエータによってノブに間歇的なクリック感触を付与するハプティック入力装置の操作性を良好なものにすることができる。

【００１９】本発明は、前記の課題を解決するため、第５に、前記メモリに、前記アクチュエータの制御信号として、前記ノブの操作に一定感触の微振動を与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記ノブの操作方向に応じて音質が異なる可聴音を連続的に発生する制御信号を記憶するという構成にした。

【００２０】このように、アクチュエータの制御信号としてノブの操作に一定感触の微振動を与える制御信号を記憶すると共に、スピーカの制御信号としてノブの操作方向に応じて音質が異なる可聴音を連続的に発生する制御信号を記憶すると、スピーカから発する音を聞くことによって、ノブの操作方向及び操作量をブラインドタッチで知ることができるので、例えばオーディオの音調調整のようにノブの操作に一定感触の微振動を与えるハプティック入力装置の操作性を良好なものにすることができる。

【００２１】本発明は、前記の課題を解決するため、第６に、前記メモリに、前記アクチュエータの制御信号として、前記ノブの操作にセンター復帰力と一定感触の微振動とセンター位置からの操作量に応じた抵抗感とを与える制御信号を記憶すると共に、前記スピーカの制御信号として、前記ノブがセンター位置に復帰したタイミングで可聴音を発生する制御信号を記憶するという構成にした。

【００２２】このように、アクチュエータの制御信号としてノブの操作にセンター復帰力と一定感触の微振動とセンター位置からの操作量に応じた抵抗感とを与える制御信号を記憶すると共に、スピーカの制御信号としてノブがセンター位置に復帰したタイミングで可聴音を発生する制御信号を記憶すると、スピーカから発する音を聞くことによってノブがセンター位置に復帰したことをブラインドタッチで知ることができるので、例えばオーディオバランスのようにセンター復帰機能を有するハプティック入力装置の操作性を良好なものにすることができる。

【００２３】

【発明の実施の形態】以下、本発明に係るハプティック入力装置の第１実施形態例を、車載電気機器の機能調整手段として適用した場合を例にとり、図１及び図２に基づいて説明する。図１は第１実施形態例に係るハプティック入力装置の構成図であり、図２は第１実施形態例に係るハプティック入力装置によって調整可能な車載電気機器の機能の種別とメモリより読み出されるアクチュエータ制御信号及びスピーカ制御信号のパターンとの関係を示す表図である。

【００２４】図１に示すように、本例のハプティック入力装置は、筐体１と、当該筐体１の内部に設置され、駆動軸２ａが前記筐体１より外部に突出されたアクチュエ

ータ２と、前記駆動軸２ａの一端に固着されたロータリノブ３と、前記駆動軸２ａの他端に固着されたコードホイール４ａ及び前記筐体１に設置されたフォトインタラプタ４ｂとからなる検知手段４と、スイッチ５と、スピーカ６と、前記アクチュエータ２及びスイッチ５並びにスピーカ６を含むシステム全体を制御する制御手段７とから主に構成されている。

【００２５】筐体１は自動車のダッシュボード或いはコンソールボックス等を構成するパネル８の内部に設置され、ロータリノブ３は当該パネル８の外部に配置される。

【００２６】アクチュエータ２は、ロータリノブ３の操作に応じた外力を発生して操作者にロータリノブ３の操作フィーリングを与えるものであって、ロータリノブ３に所要の外力を負荷可能なものであれば、回転モータ、リニアモータ又はソレノイドなど、公知に属する任意のアクチュエータを用いることができる。なお、図１には、回転モータを用いた場合が例示されている。

【００２７】ロータリノブ３は、車載電気機器の調整つまみとして使用されるものであって、プラスチックの成形品をもって所要の形状に形成される。

【００２８】検知手段４としては、ロータリノブ３の操作方向及び操作量を検知可能なものであれば、エンコーダ又は可変抵抗器など、公知に属する任意の位置検出器を用いることができるが、図１には、アクチュエータ２の駆動軸２ａに固着されたコードホイール４ａと筐体１に設置されたフォトインタラプタ４ｂとからなる光学式のロータリエンコーダが例示されている。

【００２９】スイッチ５は、ロータリノブ３を操作することによって機能を調整しようとする車載電気機器を選択するためのものであって、本例のハプティック入力装置においては、「ラジオ」を選択するための押釦スイッチ５ａと、「エアコン」を選択するための押釦スイッチ５ｂと、「カーナビゲーションシステム」を選択するための押釦スイッチ５ｃとが備えられている。

【００３０】スピーカ６は、ロータリノブ３の操作に応じた可聴音を発生して操作者にロータリノブ３の操作フィーリングを与えるものであって、操作フィーリング発生用のスピーカを車載オーディオ機器に備えられたスピーカーとは別に備えることもできるし、車載オーディオ機器に備えられたスピーカを操作フィーリング発生用のスピーカとして兼用することもできる。操作フィーリング発生用の専用スピーカを備えた場合には、何ら車載オーディオ機器の配線等を変更する必要がないので、自動車へのハプティック入力装置の適用を容易に行うことができる。一方、車載オーディオ機器に備えられたスピーカを操作フィーリング発生用のスピーカとして兼用した場合には、操作フィーリング発生用のスピーカを別途備える必要がないので、ハプティック入力装置の構成を集約化することができ、ハプティック入力装置の小型化、低コスト化及び省電力化を図ることができる。

【００３１】制御手段７は、図１に示すように、入力部７１と、当該入力部７１に入力された選択信号ａ１～ａ３及び検知信号ｂを取り込んで、アクチュエータ２の制御信号ｃ１、スピーカ６の制御信号ｃ２及び選択された車載電気機器の制御信号ｃ３を出力するＣＰＵ７２と、メモリ７３と、アクチュエータ２の駆動信号ｄ１を生成する第１ドライバ回路７４と、スピーカ６の駆動信号ｄ２を生成する第２ドライバ回路７５と、選択された車載電気機器の駆動信号ｄ３を生成する第３ドライバ回路７６と、出力部７７とから主に構成されている。

【００３２】メモリ７３には、図１に示すように、前記選択信号ａ１～ａ３及び検知信号ｂを解析するためのデータ及びプログラム並びにＣＰＵ７２の動作プログラムが記憶されたデータ・プログラム記憶部７３ａと、前記選択信号ａ１～ａ３及び検知信号ｂに対応するアクチュエータ２の制御信号ｃ１、スピーカ６の制御信号ｃ２及び選択された車載電気機器の制御信号ｃ３が記憶された制御信号記憶部７３ｂが備えられており、前記制御信号記憶部７３ｂには、図２に示すように、各車載電気機器ごとの機能選択時におけるアクチュエータ２の制御信号ｃ１０及びスピーカ６の制御信号ｃ２０と、各車載電気機器ごとの機能調整時におけるアクチュエータ２の制御信号ｃ１１～ｃ１９、スピーカ６の制御信号ｃ２１～ｃ２９及び車載電気機器の制御信号ｃ３１～ｃ３９が記憶されている。

【００３３】なお、図２の例では、選択された車載電気機器の各機能ごとに異なる制御信号ｃ１０～ｃ１９，ｃ２０～ｃ２９を設定したが、各車載電気機器の各機能ごとにアクチュエータ２の制御信号ｃ１及びスピーカ６の制御信号ｃ２を変更する必要はなく、各車載電気機器の各機能ごとにアクチュエータ２の制御信号ｃ１とスピーカ６の制御信号ｃ２の組合せを変更すれば足りる。このように、各車載電気機器の各機能ごとにアクチュエータ２の制御信号ｃ１とスピーカ６の制御信号ｃ２の組合せを変更するという構成にすると、少ないアクチュエータ２の制御信号ｃ１とスピーカ６の制御信号ｃ２とで多くの操作フィーリングを作り出すことができるので、多機能かつ多用途のハプティック入力装置を容易に設計することができる。

【００３４】ＣＰＵ７２は、入力部７１に入力された選択信号ａ１～ａ３及び検知信号ｂを取り込み、前記メモリ７３のデータ・プログラム記憶部７３ａに記憶されたデータ及びプログラムに基づいて前記選択信号ａ１～ａ３及び検知信号ｂを解析すると共に、当該データ・プログラム記憶部７３ａに記憶された動作ログラムに基づいて前記選択信号ａ１～ａ３及び検知信号ｂに対応する制御信号ｃ１～ｃ３を前記メモリ７３の制御信号記憶部７３ｂから読み出し、第１乃至第３のドライバ回路７４～７６に出力する。

【００３５】各ドライバ回路７４～７６は、ＣＰＵ７２より出力された制御信号ｃ１～ｃ３をＤ／Ａ変換するＤ／Ａ変換器と、Ｄ／Ａ変換された信号を増幅する信号増幅器とから構成されており、出力部７７を介してアクチュエータ２、スピーカ６及び図示しない車載電気機器に駆動信号ｄ１～ｄ３を出力する。

【００３６】なお、前記制御手段７は、ハプティック入力装置と一体に構成することもできるし、ハプティック入力装置とは独立の別体に構成して外部装置（例えば、自動車の車体）に備えることもできる。前記制御手段７をハプティック入力装置と一体に構成した場合には、何ら外部装置を変更する必要がないので、外部装置へのハプティック入力装置の適用を容易に行うことができる。一方、前記制御手段７をハプティック入力装置とは独立の別体に構成して外部装置に備えた場合には、外部装置に備えられた制御装置（例えば、自動車用コントローラ）を利用してハプティック入力装置を構成することができるので、制御手段７を省略することができ、安価なハプティック入力装置を提供することができる。

【００３７】以下、このように構成されたハプティック入力装置の動作を、スイッチ５によってラジオが選択された場合を例にとり、図３乃至図６に基づいて説明する。図３はラジオの機能選択時においてアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図、図４はラジオ局の選局時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図、図５はラジオの音量調整時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図、図６はオーディオバランスの調整時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図である。

【００３８】操作者が押釦スイッチ５ａを操作し、「ラジオ」が選択されると、ＣＰＵ７２はラジオの機能選択モードになり、制御信号記憶部７３ｂからのアクチュエータ２の制御信号ｃ１０及びスピーカ６の制御信号ｃ２０の読み出しが可能な状態になる。アクチュエータ２の制御信号ｃ１０は、図３に示すように、ロータリノブ３を一方向に一定量操作するごとに、間歇的にロータリノブ３に一定強度のクリック感触を与えるものであり、スピーカ６の制御信号ｃ２０は、前記クリック感触の発生タイミングに同期して感覚的にクリック感触を連想する可聴音を発生するものであって、各クリック感触に同期して発せられる可聴音は、それぞれ音程が異なっている。各クリック感触を発生するロータリノブ３の回転角度は、調整しようとするラジオの各機能、即ち、「ラジオ局の選局」又は「ラジオ音量の調整」若しくは「オーディオバランスの調整」を選択可能な回転位置に対応する検知信号ｂの値に対応しており、ロータリノブ３を所要のクリック感触が得られる位置まで回転し、図示しない決定スイッチを押すことによって、所要の機能を選択することができる。

【００３９】この状態から、操作者がロータリノブ３を回転操作すると、その回転運動が駆動軸２ａを介して検知手段４のコードホイール４ａに伝達され、フォトインタラプタ４ｂよりロータリノブ３の回転方向及び回転量に応じた検知信号ｂが出力される。ＣＰＵ７２は、この検知信号ｂに応じたアクチュエータ２の制御信号ｃ１０及びスピーカ６の制御信号ｃ２０を制御信号記憶部７３ｂから読み出し、第１及び第２のドライバ回路７４，７５に出力する。また、これら第１及び第２のドライバ回路７４，７５は、ＣＰＵ７２から出力された制御信号ｃ１０，ｃ２０に対応するアクチュエータ２の駆動信号ｄ１及びスピーカ６の駆動信号ｄ２を生成して出力する。これによって、アクチュエータ２が駆動され、ロータリノブ３に所要の外力が付与されると共に、スピーカ６からロータリノブ３に負荷される外力と関連付けられた可聴音が発せられる。したがって、操作者は、これらアクチュエータ２にて付与される外力及びスピーカ６から発せられる可聴音を感得することによって、調整しようとする所望の機能を確実に選択することができる。

【００４０】機能が選択された後、ＣＰＵ７２は機能の調整モードになり、データ・プログラム記憶部７３ａからのアクチュエータ２の制御信号ｃ１１～ｃ１３及びスピーカ６の制御信号ｃ２１～ｃ２３の読み出しが可能な状態になる。アクチュエータ２の制御信号ｃ１１及びスピーカ６の制御信号ｃ２１は、「ラジオ局の選局」が選択された場合に読み出しが可能になる制御信号であり、アクチュエータ２の制御信号ｃ１２及びスピーカ６の制御信号ｃ２２は、「ラジオ音量の調整」が選択された場合に読み出しが可能になる制御信号であり、アクチュエータ２の制御信号ｃ１３及びスピーカ６の制御信号ｃ２３は、「オーディオバランスの調整」が選択された場合に読み出しが可能になる制御信号である。

【００４１】図４に示すように、アクチュエータ２の制御信号ｃ１１は、ロータリノブ３を一方向に一定量操作するごとに、間歇的にロータリノブ３にダブルクリック感触を与えるものである。また、スピーカ６の制御信号ｃ２１は、前記クリック感触の発生タイミングに同期して感覚的にクリック感触を連想する可聴音を発生するものであって、図３に示したスピーカ６の制御信号ｃ２０とは、発せられる音の長さが異なっている。各クリック感触を発生するロータリノブ３の回転角度は、選択しようとするラジオ局（局１、局２、局３・・・）を選択するときの回転位置に対応する検知信号ｂの値に対応しており、ロータリノブ３を所要のクリック感触が得られる位置まで回転し、図示しない決定スイッチを押すことによって、所要のラジオ局を選択する図５に示すように、アクチュエータ２の制御信号ｃ１２は、ロータリノブ３

の回転操作に応じてロータリノブ３に連続的に微振動を与えるものであり、スピーカ６の制御信号ｃ２２は、ロータリノブ３の回転操作に応じて感覚的に微振動を連想する可聴音を発生するものである。ロータリノブ３の回転角度は、ラジオの音量を調整するときの回転位置に対応する検知信号ｂの値に対応しており、ロータリノブ３の右転又は左転に応じて、ラジオ局の音量を調整する。

【００４２】図６に示すように、アクチュエータ２の制御信号ｃ１３は、ロータリノブ３の回転操作に応じてロータリノブ３に連続的に微振動を与えると共に、ロータリノブ３の回転量に比例してロータリノブ３に作用する抵抗感を増加し、かつ、ロータリノブ３から手を離したときにロータリノブ３が自動的に予め定められたセンター位置に復帰させるものである。また、スピーカ６の制御信号ｃ２３は、ロータリノブ３の回転操作に応じて感覚的に微振動及び抵抗感の増減を連想する可聴音を発生すると共に、ロータリノブ３がセンター位置に復帰したとき、それを操作者に報知する音量の可聴音を発生するものである。ロータリノブ３の回転角度は、オーディオバランスを調整するときの回転位置に対応する検知信号ｂの値に対応しており、ロータリノブ３の右転又は左転に応じて、オーディオバランスを所定の値に調整する。

【００４３】したがって、スイッチ５を操作することによってラジオを選択し、次いで、ロータリノブ３を操作して調整しようとする所要の機能を選択した後に、操作者がロータリノブ３を回転操作すると、その回転運動が駆動軸２ａを介して検知手段４のコードホイール４ａに伝達され、フォトインタラプタ４ｂよりロータリノブ３の回転方向及び回転量に応じた検知信号ｂが出力されて、メモリ７の制御信号記憶部７３ｂから検知信号ｂに応じた所要の制御信号ｃ１１～ｃ１３及びｃ２１～ｃ２３が読み出され、第１及び第２のドライバ回路７４，７５から制御信号ｃ１１～ｃ１３及びｃ２１～ｃ２３に応じたアクチュエータ２の駆動信号ｄ１及びスピーカ６の駆動信号ｄ２が出力される。したがって、操作者は、これらアクチュエータ２にて付与される外力及びスピーカ６から発せられる可聴音を感得することによって、所望の機能の調整を確実に選択することができる。

【００４４】本例のハプティック入力装置は、制御手段７に備えられたメモリ７３にアクチュエータ２の制御信号ｃ１０～ｃ１９とスピーカ６の制御信号ｃ２０～ｃ２９とを記憶しておき、ロータリノブ３が操作されたときに、制御手段７が当該メモリ７３より読み出された制御信号に基づいてアクチュエータ２の駆動信号ｄ１及びスピーカ６の駆動信号ｄ２を生成し、操作者にアクチュエータ２より与えられる外力及びスピーカ６より発生される可聴音の組合せに応じたロータリノブ３の操作フィーリングを与えるという構成にしたので、操作者はロータリノブ３に加えれたアクチュエータ２の外力及びスピーカ６から発せられる可聴音の双方によってロータリノブ３の操作状態をブラインドタッチで知ることができ、例えば未舗装路を走行中の場合のように車体の振動が大きい場合にもロータリノブ３の操作フィーリングを正確に感得することができて、所望の機器の選択や選択された機器の機能調整を迅速かつ確実に行うことができる。また、メモリ７３にそれぞれ複数のアクチュエータ２の制御信号及びスピーカ６の制御信号を記憶するので、それらの組合せによって多種多様なロータリノブ３の操作フィーリングを作り出すことができ、ハプティック入力装置の多機能化及び多用途化を図ることができる。

【００４５】次に、本発明に係るハプティック入力装置の第２実施形態例を、図７に基づいて説明する。図７は第２実施形態例に係るハプティック入力装置に備えられる制御手段の構成図である。

【００４６】図７に示すように、本例のハプティック入力装置の制御手段７Ａには、第１実施形態例に係るハプティック入力装置のメモリ７３に記憶されたデータ・プログラム記憶部７３ａ及び制御信号記憶部７３ｂのほかに、スイッチ５によって選択された車載電気機器の機能選択時にスピーカ６より発せられる他の可聴音及び選択された機能の調整時にスピーカ６より発せられる他の可聴音が記憶された第２可聴音記憶部７３ｃ及び第３可聴音記憶部７３ｄを有するメモリ７３Ａが備えられている。制御信号記憶部７３ｂに記憶された可聴音は高級感を感じさせる音質を有し、第２可聴音記憶部７３ｃに記憶された可聴音はスポーティ感を感じさせる音質を有し、第３可聴音記憶部７３ｄに記憶された可聴音は軽快感を感じさせる音質を有しており、いずれの記憶部からスピーカ６の制御信号を読み出すかは、制御手段７Ａに備えられた切替スイッチ９を操作することによって行われる。その他については、第１実施形態例に係るハプティック入力装置と同じであるので、対応する部分に同一の符号を付して説明を省略する。

【００４７】本例のハプティック入力装置は、メモリ７３Ａに、高級感を感じさせる音質の制御信号、スポーティ感を感じさせる音質の制御信号及び軽快感を感じさせる音質の制御信号を記憶し、切替スイッチ９によって各記憶部から読み出される制御信号を切り換えられるようにしたので、１つのハプティック入力装置を高級車、スポーツカー及び大衆車のそれぞれに最適な操作感を与えるために適用することが可能で、量産効果によるハプティック入力装置の低コスト化を図ることができる。

【００４８】次に、本発明に係るハプティック入力装置の第３実施形態例を、図８に基づいて説明する。図８は第３実施形態例に係るハプティック入力装置に備えられる制御手段の構成図である。

【００４９】図８に示すように、本例のハプティック入力装置の制御手段７Ｂには、第１実施形態例に係るハプティック入力装置のメモリ７３に記憶されたデータ・プログラム記憶部７３ａ及び制御信号記憶部７３ｂのほか

に、ロータリノブ３による車載電気機器の機能選択又は機能調整が正当に行われなかった場合にスピーカ６より発せられる警報音が記憶された第４可聴音記憶部７３ｅを有するメモリ７３Ｂと、ロータリノブ３による車載電気機器の機能選択又は機能調整が正当に行われたか否かを判定する不正操作判定部１０とが備えられている。不正操作判定部１０は、例えば走行中におけるカーナビゲーションシステムの目的地設定など、安全上禁止されている操作が誤って行われた場合、或いは、ノブが予め定められた可動範囲外に操作された場合、自動的にこれらの不正操作を検知し、メモリ７３Ｂから読み出されるロータリノブ３の制御信号を、制御信号記憶部７３ｂに記憶された制御信号から第４可聴音記憶部７３ｅに記憶された制御信号に切り換えて、操作者に所定の警報を発する。その他については、第１実施形態例に係るハプティック入力装置と同じであるので、対応する部分に同一の符号を付して説明を省略する。

【００５０】なお、本例においては、ロータリノブ３が不正操作された場合に、警報音のみを発生する構成としたが、警報音に代えてアクチュエータ２より警報用の外力をロータリノブ３に付与することもできるし、警報音及び警報用の外力の双方を発生するようにすることもできる。

【００５１】本例のハプティック入力装置は、制御手段７Ｂにロータリノブ３が不正操作されたか否かを判定する不正操作判定部１０を備え、当該不正操作判定部１０にてロータリノブ３が不正操作されたと判定された場合に、メモリ７３より操作者に異常な操作感を与える制御信号を読み出してスピーカ６を駆動するようにしたので、当該ハプティック入力装置が適用される機器の不正操作やロータリノブ３の不正操作を防止することができ、安全性及び信頼性に優れる。

【００５２】なお、前記各実施形態例においては、ノブとしてロータリノブを用いた場合を例にとって説明したが、本発明の要旨はこれに限定されるものではなく、ノブとしてスティックレバーを用いることもできるし、ロータリノブとスティックレバーの双方を用いることもできる。

【００５３】また、前記各実施形態例においては、ハプティック入力装置を車載電気機器の機能調整手段として適用した場合のみを例にとって説明したが、本発明の要旨はこれに限定されるものではなく、ゲーム機その他の入力装置として適用することももちろん可能である。

【００５４】

【発明の効果】本発明のハプティック入力装置は、制御手段に備えられたメモリにアクチュエータの制御信号とスピーカの制御信号とを記憶しておき、ロータリノブが操作されたときに、制御手段が当該メモリより読み出された制御信号に基づいてアクチュエータの駆動信号及びスピーカの駆動信号を生成し、操作者にアクチュエータより与えられる外力及びスピーカより発生される可聴音の組合せよりなるロータリノブの操作フィーリングを与えるので、操作者はロータリノブに加えられたアクチュエータの外力及びスピーカから発せられる可聴音の双方によってロータリノブの操作状態をブラインドタッチで知ることができ、ロータリノブの操作フィーリングを正確に感得することができて、所望の機器の選択や選択された機器の機能調整を迅速かつ確実に行うことができる。また、メモリにそれぞれ複数のアクチュエータの制御信号及びスピーカの制御信号を記憶するので、それらの組合せによって多種多様なロータリノブ３の操作フィーリングを作り出すことができ、ハプティック入力装置の多機能化及び多用途化を図ることができる。

【図面の簡単な説明】

【図１】第１実施形態例に係るハプティック入力装置の構成図である。

【図２】第１実施形態例に係るハプティック入力装置によって調整可能な車載電気機器の機能の種別とメモリより読み出されるアクチュエータ制御信号及びスピーカ制御信号のパターンとの関係を示す表図である。

【図３】ラジオの機能選択時においてアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図である。

【図４】ラジオ局の選局時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図である。

【図５】ラジオの音量調整時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図である。

【図６】オーディオバランスの調整時にアクチュエータよりロータリノブに加えられる外力とスピーカより発せられる可聴音とを模式的に示す説明図である。

【図７】第２実施形態例に係るハプティック入力装置に備えられる制御手段の構成図である。

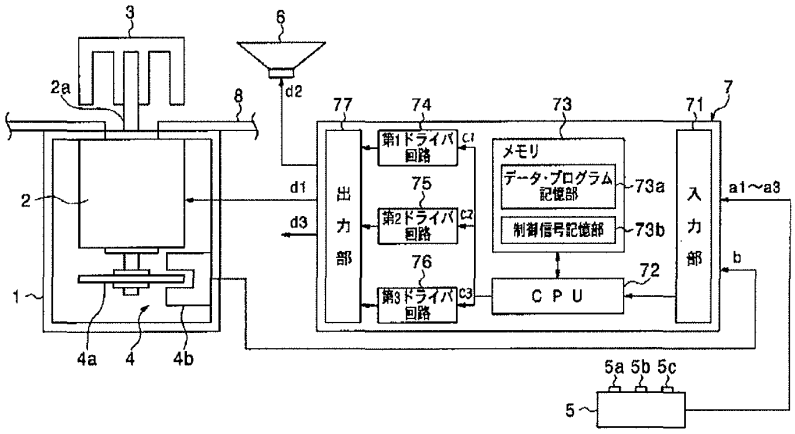
【図８】第３実施形態例に係るハプティック入力装置に備えられる制御手段の構成図である。

【図９】従来例に係る手動入力装置の構成図である。

【符号の説明】

２　アクチュエータ
３　ロータリノブ
４　検知手段
６　スピーカ
７　制御手段
９　切替スイッチ
１０　不正操作判定部

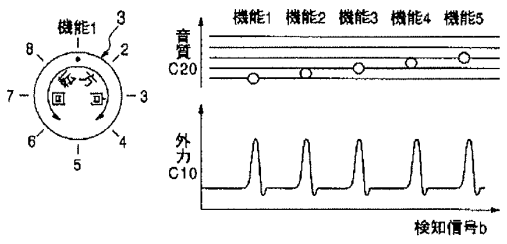
【図１】



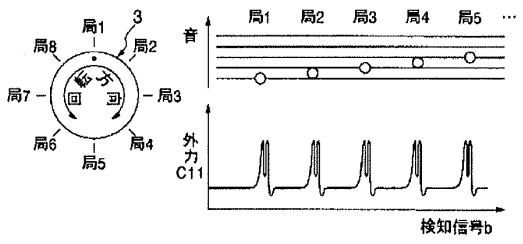
【図２】

スイッチ5の操作によって選択される車載電気機器	機能選択時		ロータリノブ3の操作によって選択される機能	機能調整時		
	アクチュエータ制御信号	スピーカ制御信号		アクチュエータ制御信号	スピーカ制御信号	機器制御信号
ラジオ	C10	C20	選局	C11	C21	C31
			音量調整	C12	C22	C32
			オーディオバランスの調整	C13	C23	C33
エアコン	C11	C25	温度設定	C14	C24	C34
			風量設定	C15	C25	C35
			吹出口設定	C16	C26	C36
カーナビゲーションシステム	C13	C29	画面のスクロール	C17	C27	C37
			画面切替	C18	C28	C38
			目的地設定	C19	C29	C39

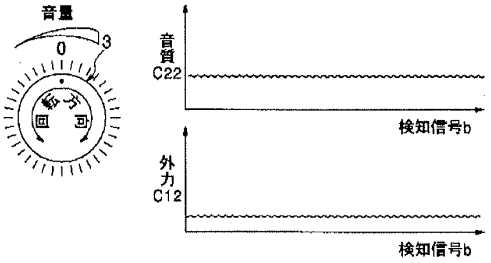
【図３】



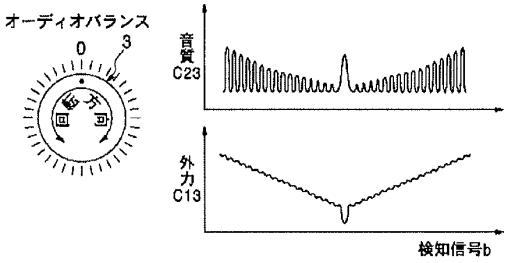
【図４】



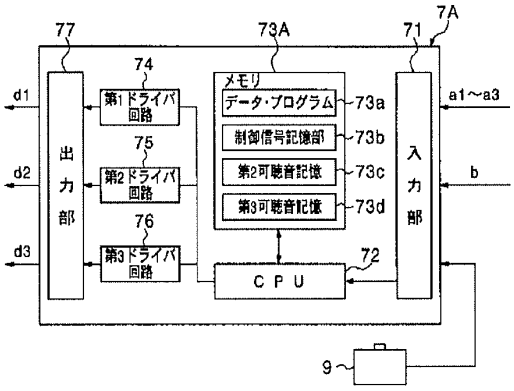
【図５】


音量
0
3
音質
C22
検知信号b
外力
C12
検知信号b

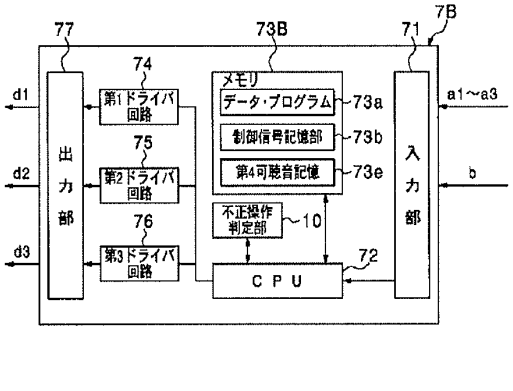
【図６】


オーディオバランス
0
3
音質
C23
外力
C13
検知信号b

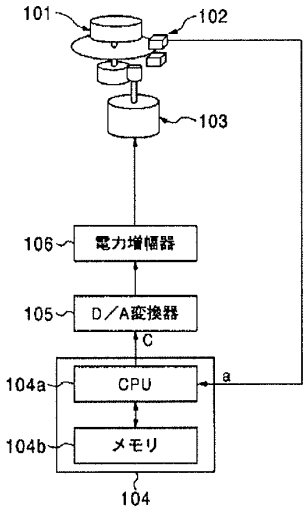
【図７】


77
73A
71
7A
74
メモリ
d1
第1ドライバ回路
データ・プログラム
73a
a1～a3
出力部
75
制御信号記憶部
73b
d2
第2ドライバ回路
第2可聴音記憶
73c
b
入力部
76
第3可聴音記憶
73d
d3
第3ドライバ回路
72
CPU
9

【図８】


77
73B
71
7B
74
メモリ
d1
第1ドライバ回路
データ・プログラム
73a
a1～a3
出力部
75
制御信号記憶部
73b
d2
第2ドライバ回路
第4可聴音記憶
73e
b
入力部
76
不正操作判定部
10
d3
第3ドライバ回路
72
CPU

【図９】


101
102
103
106
電力増幅器
105
D／A変換器
C
104a
CPU
a
104b
メモリ
104

Espacenet

Bibliographic data: JP2006163206 (A) — 2006-06-22

TACTILE SENSE PRESENTATION DEVICE

Inventor(s): HAYASHI HIROKI; MANABE HIROYUKI; OYA TOMOYUKI ± (HAYASHI HIROKI, ; MANABE HIROYUKI, ; OYA TOMOYUKI)

Applicant(s): NTT DOCOMO INC ± (NTT DOCOMO INC)

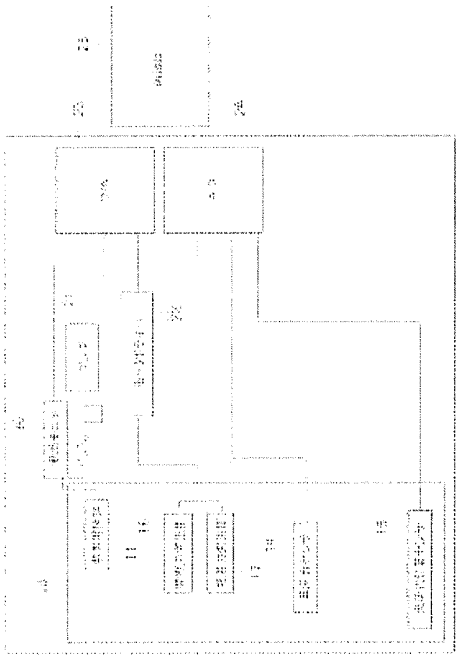
Classification: **- international:** ***G06F3/01; G09B21/00***
- cooperative:

Application number: JP20040357349 20041209

Priority number (s): JP20040357349 20041209

Abstract of JP2006163206 (A)

PROBLEM TO BE SOLVED: To present a tactile sense presentation device capable of presenting a tactile sense corresponding to a feeling of touch and an operating direction only by one device. ;SOLUTION: The movable tactile sense presentation device 10 is provided with a frictional force generation part 16 for generating frictional force, a driving force generation part 17 for generating driving force and a stimulus electrode part 11 for presenting information through a tactile sense by using the frictional force generated from the frictional force generation part 16 and the driving force generated from the driving force generation part 17. ;COPYRIGHT: (C) 2006,JPO&NCIPI



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G06F 3/01	(2006.01)	G06F	3/00 680A	

審査請求 未請求　請求項の数 6　OL　（全 27 頁）

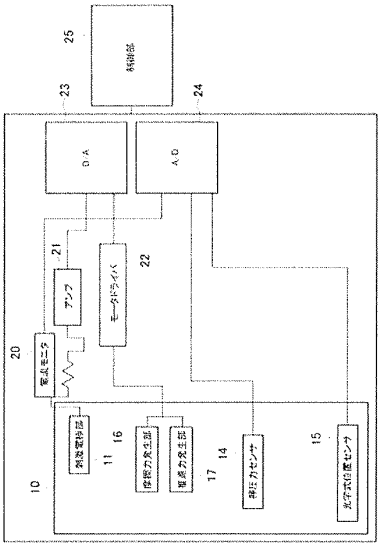
(21)出願番号　特願2004-357349 (P2004-357349)
(22)出願日　平成16年12月9日 (2004.12.9)

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最終頁に続く

(54)【発明の名称】触覚提示装置

(57)【要約】
【課題】一つのデバイスで、触り心地や動作方向に応じた触覚を提示することが可能な触覚提示装置を提供する。
【解決手段】移動可能な触覚提示装置１０は、摩擦力を発生させる摩擦力発生部１６と、推進力を発生させる推進力発生部１７と、摩擦力発生部１６から発生される摩擦力と、推進力発生部１７から発生される推進力とを用いて、触覚を通じて情報を提示する刺激電極部１１とを備える。
【選択図】図１



【特許請求の範囲】
【請求項１】
移動可能な触覚提示装置であって、
摩擦力を発生させる摩擦力発生部と、
推進力を発生させる推進力発生部と、
前記摩擦力発生部から発生される摩擦力と、前記推進力発生部から発生される推進力とを用いて、触覚を通じて情報を提示する出力部と
を備えることを特徴とする触覚提示装置。
【請求項２】
前記触覚提示装置の位置、速度、加速度のいずれか１を検出する第１のセンサを更に備えることを特徴とする請求項１に記載の触覚提示装置。
【請求項３】
前記出力部への物体の押圧力を検出する第２のセンサを更に備えることを特徴とする請求項１又は２に記載の触覚提示装置。
【請求項４】
前記出力部は、電気刺激によって前記情報を提示する刺激電極部であることを特徴とする請求項１～３のいずれか１項に記載の触覚提示装置。
【請求項５】
前記第２のセンサによって検出される押圧力に従って、前記摩擦力あるいは前記推進力を制御することを特徴とする請求項３に記載の触覚提示装置。
【請求項６】
前記第１のセンサによって検出される位置、速度、加速度、あるいは前記第２のセンサによって検出される押圧力に従って、前記摩擦力あるいは前記推進力あるいは前記電気刺激の波形パターンを制御することを特徴とする請求項４に記載の触覚提示装置。

【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、移動可能な触覚提示装置に関する。
【背景技術】
【０００２】
従来、健常者向けの皮膚を介した文字情報やＧＵＩ（グラフィカルユーザインタフェース）操作を、触覚を通じて提示する触覚提示装置がある。
【０００３】
このような触覚提示装置において、摩擦力を用いて情報を提示する技術（例えば、特許文献１参照。）や、ＧＵＩ操作を提示する技術（例えば、特許文献２参照。）が開示されている。
【０００４】
又、機械的な刺激装置を使用しているものは、全般的に触覚提示部分に大きな体積を必要とするため、触覚提示部分に電気刺激を用いる技術も開示されている（例えば、特許文献３参照。）。
【特許文献１】特開平６－１９３８５号公報
【特許文献２】実用新案登録第３０８４４３３号公報
【特許文献３】特開２００２－３２８５９６号公報
【発明の開示】
【発明が解決しようとする課題】
【０００５】
しかしながら、上述した従来技術では、氷のようにスベスベとした物体表面などの触り心地を提示したり、ＧＵＩ操作において、指の動作方向に応じた触覚を提示したりすることは困難であった。

【０００６】
又、従来、触覚を通じた文字情報の提示やＧＵＩ操作補助を一つのデバイスで達成することはできず、それぞれの目的を達成するために、別々のデバイスを必要としていた。
【０００７】
そこで、本発明は、上記の課題を鑑み、一つのデバイスで、触り心地や動作方向に応じた触覚を提示することが可能な触覚提示装置を提供することを目的とする。
【課題を解決するための手段】
【０００８】
上記目的を達成するため、本発明の特徴は、移動可能な触覚提示装置であって、（ａ）摩擦力を発生させる摩擦力発生部と、（ｂ）推進力を発生させる推進力発生部と、（ｃ）摩擦力発生部から発生される摩擦力と、推進力発生部から発生される推進力とを用いて、触覚を通じて情報を提示する出力部とを備える触覚提示装置であることを要旨とする。
【０００９】
本発明の特徴に係る触覚提示装置によると、摩擦力だけでなく、推進力を発生させることにより、一つのデバイスで、触り心地や動作方向に応じた触覚を提示することができる。
【００１０】
又、本発明の特徴に係る触覚提示装置は、触覚提示装置の位置、速度、加速度のいずれか１を検出する第１のセンサを更に備えてもよい。
【００１１】
この触覚提示装置によると、触覚提示装置の位置、速度、加速度に応じた情報を提示することができる。
【００１２】
又、本発明の特徴に係る触覚提示装置は、出力部への物体（例えば、指など）の押圧力を検出する第２のセンサを更に備えてもよい。
【００１３】
この触覚提示装置によると、物体の押圧力に応じた情報を提示することができる。
【００１４】
又、本発明の特徴に係る触覚提示装置の出力部は、電気刺激によって情報を提示する刺激電極部であってもよい。
【００１５】
この触覚提示装置によると、電気式の刺激装置を用いることで、デバイスの小型化が可能となる。
【００１６】
又、本発明の特徴に係る触覚提示装置は、第２のセンサによって検出される押圧力に従って、摩擦力あるいは推進力を制御してもよい。
【００１７】
又、本発明の特徴に係る触覚提示装置は、第１のセンサによって検出される位置、速度、加速度、あるいは第２のセンサによって検出される押圧力に従って、摩擦力あるいは推進力あるいは電気刺激の波形パターンを制御してもよい。
【発明の効果】
【００１８】
本発明によると、一つのデバイスで、触り心地や動作方向に応じた触覚を提示することが可能な触覚提示装置を提供することができる。
【発明を実施するための最良の形態】
【００１９】
次に、図面を参照して、本発明の実施の形態を説明する。以下の図面の記載において、同一又は類似の部分には、同一又は類似の符号を付している。ただし、図面は模式的なものであり、各寸法の比率等は現実のものとは異なることに留意すべきである。従って、具体的な寸法等は以下の説明を参酌して判断すべきものである。又、図面相互間においても

互いの寸法の関係や比率が異なる部分が含まれていることは勿論である。

【００２０】

本発明の実施形態に係る触覚提示装置は、「布などの触り心地提示」と「皮膚を介した文字提示」と「ＧＵＩ操作時の触覚フィードバック」とを達成することができる。

【００２１】

（第１の実施の形態）

第１の実施の形態では、触覚提示装置を用いた「布などの触り心地提示」について説明する。

【００２２】

第１の実施の形態に係る触覚提示装置は、移動可能な装置であり、例えば、マウスなどの入力装置の他、携帯電話などの通信端末であってもよい。触覚提示装置１０は、図１に示すように、摩擦力を発生させる摩擦力発生部１６と、推進力を発生させる推進力発生部１７と、摩擦力発生部から発生される摩擦力と、推進力発生部から発生される推進力とにより、触覚を通じて情報を提示する出力部（例えば、電気刺激によって情報を提示する刺激電極部１１）とを備える。又、触覚提示装置１０は、触覚提示装置１０の位置、速度、加速度のいずれか１を検出する第１のセンサ（光学式位置センサ１５）と、刺激電極部１１への物体の押圧力を検出する第２のセンサ（押圧力センサ１４）とを備える。

【００２３】

又、触覚提示装置１０は、押圧力に従って、摩擦力あるいは推進力を制御する。又、触覚提示装置１０は、光学式位置センサ１５によって検出される位置、速度、加速度、あるいは押圧力センサ１４によって検出される押圧力に従って、摩擦力あるいは推進力あるいは電気刺激の波形パターンを制御する。

【００２４】

摩擦力発生部１６及び推進力発生部１７は、例えば、アクチュエータ付きキャスターを使用することができる。アクチュエータとしては、例えば、モータが挙げられる。

【００２５】

図１では、触覚提示装置１０の外部に、電流モニタ２０と、アンプ２１と、モータドライバ２２と、Ｄ／Ａ変換器２３と、Ａ／Ｄ変換器２４と、触覚提示装置１０、電流モニタ２０、アンプ２１、モータドライバ２２、Ｄ／Ａ変換器２３、Ａ／Ｄ変換器２４を制御する制御部２５とを配置する構成としているが、触覚提示装置１０の内部に、電流モニタ２０と、アンプ２１と、モータドライバ２２と、Ｄ／Ａ変換器２３と、Ａ／Ｄ変換器２４と、制御部２５とを備える構成としても構わない。

【００２６】

第１の実施の形態に係る触覚提示装置の使用について、図２及び図３を用いて具体的に説明する。人間は、布などの触り心地を得る場合、人差し指などを布の上で左右に動かすことで表面のザラザラ、スベスベなどを認識する。

【００２７】

第１の実施の形態においても、触覚提示装置１０の刺激電極部１１に指を乗せ、左右に動かすことで布などの触り心地を感じることが可能である。尚、図２（ａ）は、触覚提示装置１０を正面から見た図、図２（ｂ）は、裏面から見た図、図２（ｃ）は、側面から見た図である。又、図３（ａ）は、触覚提示装置１０を側面から見た断面図、図３（ｂ）は、触覚提示装置１０を正面から見た拡大図である。

【００２８】

図２（ａ）及び図３（ａ）に示すように、刺激電極部１１上に指３０を乗せ、触覚提示装置１０全体を左右上下などに動かす。すると、アクチュエータ付きキャスター３３は、触覚提示装置１０の動作方向に応じた触覚を提示することができる。又、アクチュエータ付きキャスター３３は、図３（ｂ）に示すように、アクチュエータ３５と、キャスター３４とから構成される。尚、図３（ａ）に示すスイッチ３１は、指３０が乗せられ、その押圧力によって、図の下方向へ下がるが、スイッチ３１の詳細については、第３の実施の形態において説明する。

【００２９】
次に、アクチュエータ付きキャスター３３（摩擦力発生部及び推進力発生部）による、触覚提示の原理について、詳細に説明する。
【００３０】
第１の実施の形態では、刺激電極部１１上に再現したい物体表面と指３０との摩擦係数μ１と物体表面形状の波長λ１を設定することで物体表面を模擬的に再現する。使用方法としては、触覚提示装置１０の刺激電極部１１に指先を置き、その指で刺激電極部１１を押し付けながら、ある平らな面で左右に動かす。摩擦力は、アクチュエータ付キャスターの発生力により、摩擦係数μ１を用いて再現され、物体表面形状の波長λ１は、電気刺激による振動刺激により再現される。再現したい物体表面の図を図４に示す。摩擦係数μ１、物体表面の波長λ１の物体表面を模擬的に再現したい場合の詳細を以下に示す。
【００３１】
まず、布などの触り心地提示の際に必要なパラメータを図５に示す。再現したい物体表面の波長をλ１、再現したい物体表面と指の摩擦係数をμ１、触覚提示装置１０の動く速度（速度センサより取得）をＶ、指の触覚提示装置１０への押圧力（押圧力センサ１４により取得）をＦｐ、アクチュエータ付きキャスター３３の発生力（複数あるキャスター、すべての合力）をＦ、触覚提示装置の系全体と触覚提示装置を動かす平らな面との初期の摩擦係数をμ0とする。μ0は理想的には０であるが、アクチュエータとキャスターの摩擦係数などが存在するため、考慮する必要がある。
【００３２】
また、電気刺激のパラメータについて、図６に示す。電気刺激はパルス波で行い、パルス頻度をｆ、パルス幅をｗ、電流値をＩとする。
【００３３】
摩擦係数μ1を再現する場合、キャスターの発生力ＦはＶとＦｐの関数となる。即ち
Ｖ＝０の場合
Ｆ＝０
Ｖ＞０の場合
Ｆ＝（μ1－μ0）・Ｆｐ
となる。
【００３４】
又、μ1＞μ0の場合、Ｆの発生する方向は、図１０（ａ）に示すように速度Ｖのベクトルと常に１８０度向きが逆の方向となる。触覚提示装置に指を置いただけの状態で速度Ｖ＝０の場合は、キャスターの発生力は０であり、摩擦力は発生していない。指により触覚提示装置が動き始めＶ＞０となると、動かしている方向と逆向きにＦ＝（μ1－μ0）・Ｆｐの力を発生する（図１０（ｂ）参照。）。この（μ1－μ0）・Ｆｐが摩擦力となる。Ｖ＞０の状態では、指の押圧力のみの関数となり、押圧力が大きくなれば、摩擦力Ｆも大きくなる。ここでは、キャスターを動かすアクチュエータはモータを想定しているが、発生力Ｆを発生可能なアクチュエータであれば、特定するものではない。摩擦係数は、０．０から５．０まで再現可能であれば好ましい。また、キャスターと触覚提示装置１００を動かしているある平らな面との摩擦係数は理想的には無限大である。キャスターには摩擦係数が高いゴムなどが理想である。キャスターの摩擦係数、キャスターを駆動するアクチュエータなどの要素により、各パラメータの調整が必要になると考えられる。
【００３５】
一方、μ1＜μ0の場合、Ｆの発生する方向は、図１１（ａ）に示すように速度Ｖのベクトルと同じ方向となる。μ1とμ0の大小により変化するパラメータは、発生する力Ｆの方向のみである（図１１（ｂ）参照。）。
【００３６】
又、第１の実施の形態では、物体表面形状の波長λ1を模擬的に再現するために、電気刺激を用いる。
【００３７】

次に、刺激電極部１１の拡大図を図７に示す。使用者は、前述したように触覚提示装置１０の刺激電極部１１に指を乗せ、触覚提示装置１０全体を左右に動かす。刺激電極部１１の電極配置は図８のようになっている。刺激電極の数については、図８では３０チャンネルだが、数に制限はない。

【００３８】

第１の実施の形態における振動覚再現の際には、指に接している刺激電極４１すべてから刺激を行う。刺激の電流値については、出力している合計の電流値が１．８［ｍＡ］程度が適当である。刺激電流にはパルス波を用いる。電流は、刺激電流から刺激電極の周りに配置している不関電極へ流れる（陽極性刺激）。駆動電圧は、＋１５０～－１５０［Ｖ］以上あれば、問題ない。それより小さくなると、刺激電極と指との接触インピーダンスが高すぎて、思い通りの電流を出力できない可能性がある。不関電極４０について、図８のように刺激電極４１の周りに配置することが適当と考えられるが、手のひらや刺激電極４１と違う他の指と接するような位置に不関電極４０が配置されていても問題は無い。

【００３９】

ここで刺激について、図７を用いて、簡単に説明する。刺激電極４１から流れる電流は、感覚受容器４３に繋がる神経４４を刺激する。これにより、刺激された神経４４に繋がる感覚受容器４３が模擬的に発火し、振動覚が得られる。得られる振動覚の周波数は、パルス波のパルス頻度とほぼ同様の周波数で得られる。即ち、２０［Ｈｚ］のパルス波で電気刺激を行えば、２０［Ｈｚ］で振動しているような振動覚が得られる。

【００４０】

触覚提示装置１０の刺激電極部１１に指を置き、電気刺激を指３０に与えることで振動覚を再現する。与える振動数は、電気刺激に用いるパルス頻度ｆ［Ｈｚ］と同じであり、図９に示すように、再現したい物体表面の波長λ1と触覚提示装置の動作速度Ｖの関数で与える。即ち、電気刺激に用いるパルス頻度ｆ［Ｈｚ］は、触覚提示装置の動作速度Ｖ［ｍｍ／ｓ］と再現したい物体表面の波長λ1［ｍｍ］とすると以下のように表される。

【００４１】

$$f = V / \lambda 1$$

ただし、触覚提示装置１０の動作速度は、操作者が動かしているため一定ではなく、常に変化する。そのため、電気刺激に用いるパルス頻度も常に変化する必要がある。そこで、図６に示すように、触覚提示装置１０の動作速度Ｖの計測周期Ｔを設定することで、Ｔ周期でパルス頻度を変化させる。Ｔは１００［ｍｓｅｃ］程度が適当であるが、制限はない。図６でいう、０，ｔ1，ｔ2，ｔ3のタイミングでパルス波が出力される。Ｔ＝１００［ｍｓｅｃ］の場合、出力するパルス波が１０［Ｈｚ］（ｆ＝１／Ｔ）より小さくなることはない。

【００４２】

以上のようにして、布などの触り心地を、摩擦力と振動覚の再現により模擬的に再現する。再現したい摩擦係数および物体表面の波長については、操作者で設定可能である。ＰＣなどの制御マシンにより、再現したいパラメータを設定することが考えられる。また、遠隔地にある触覚センサなどにより摩擦係数と物体表面の波長をセンシングし、触覚提示装置に伝送し、そのまま再現することも考えられる。

【００４３】

第１の実施の形態に係る触覚提示装置１０によると、摩擦力及び推進力発生機構（アクチュエータ付きキャスター３３）を触覚提示装置１０の駆動部分として持つため、摩擦力だけでなく、推進力を発生可能となる。これにより、今まで成し得なかった物体表面形状の再現が可能となる。

【００４４】

又、振動覚再現に電気式の触覚ディスプレイ（刺激電極部１１）を用いるため、従来よりも小型のデバイスを作成することができる。

【００４５】

（第２の実施の形態）

第２の実施の形態では、触覚提示装置を用いた「皮膚を介した文字提示」について説明する。皮膚を介した文字提示には、大きく２つのモード、「順次提示モード」と「移動スリットモード」とがある。それぞれについて、以下に詳細を示す。尚、刺激電極部１１を示した図において、不関電極４０を記載していないが、図８のように刺激電極４１の周囲に不関電極４０が配置されても良い。

【００４６】

（１）順次提示モード

順次提示モードとは、指先を触覚提示装置１０の刺激電極部１１に置き、使用する。刺激電極４１の刺激チャンネルを文字の書き順に倣って時間的に変化することで、指先に対して、鉛筆やペンなどでなぞられたような感覚を提示する。

【００４７】

例えば、触覚提示装置１０が通信機能を有する携帯電話である場合、メールを受信した際、メール文章をモニタ画面を見ることなく、触覚提示装置１０の刺激電極部１１に指を押し付けることで、メールを読むことができる。勿論、触覚提示装置１０をＰＣなどの通信端末に接続し、ＰＣで受信したメールを読むことも可能である。

【００４８】

これにより、授業中や会議中など、携帯電話でメールの内容を確認することが難しい場面でも、ポケットの中の触覚提示装置１０を触ることでメールの内容が確認可能になる。

【００４９】

以下に、第２の実施の形態に係る触覚提示装置１０の機能について、詳細に説明する。

【００５０】

図１２（ａ）は、ＰＣのモニタに出力されたメールの文字列を示す。この文字列を、触覚提示装置１０を用いて読むこととする。図１２（ｂ）は、メールの文字列の内、カタカナの「ン」を触覚提示する場合を示す。「ン」の場合、画数は２画で、書き順に倣って出力電極を変化させると、各チャンネルにおける電流の出力パターンは図１３のようになる。即ち、電気刺激にはパルス波を使用し、書き順に倣って出力する電極が時系列的に変化する。尚、図１２（ｂ）は、刺激電極４１が３０チャンネルの場合を示すが、電極の数は３０チャンネルでなくても良い。

【００５１】

具体的な順次提示モードパラメータとしては、１つの電極の「電流出力時間」「周波数」「パルス幅」、それぞれの電極の「出力電流値（極性含む）」、「次の出力チャンネルに移るときのインターバル時間」、「１画目から２画目へ（次の画数に移る時）のインターバル時間」、「次の文字を提示するまでのインターバル時間」がある。各文字に対して、書き順の順番を示すデータを持つ必要がある。「ン」の場合、図１２（ｂ）のような、出力電極の順番を示すデータが必要である。順次提示モードパラメータは、操作者によって認識しやすいパラメータに個別に設定可能とする。順次提示モードパラメータの目安としては、電流出力時間は、刺激電極の間隔にもよるが、電極間隔が２［ｍｍ］の場合、１００［ｍｓｅｃ］程度が良い。周波数は４００［Ｈｚ］、パルス幅は出力電流値にもよるが、２００［μｓｅｃ］、出力電流値は１．４［ｍＡ］、次のチャンネルに移るときのインターバル時間は０～５０［ｍｓｅｃ］程度、１画目から２画目へのインターバル時間は２００［ｍｓｅｃ］程度が良い。しかし、それぞれのパラメータはあくまで目安である。順次提示モードに関しては、特願２００３－３２３５２３に示される手法を使用しても良い。

【００５２】

（２）移動スリットモード

移動スリットモードでは、触覚提示装置１０をＰＣなどに接続し、マウスとして使用する。図１４に示すように、映像モニタ５０上に映し出されたマウスポインタ５１は、触覚提示装置１０の動きに合わせて動き、映像モニタ５０に映し出された文字にマウスポインタ５１が重なると、文字にあたる刺激電極４１から電流が出力される。図１５は、マウスポインタ５１が図１４に示す状態の場合の、刺激電極の様子である。マウスポインタ５１

内の黒い部分にあたる刺激電極４１から同時に電流を出力する。移動スリットモードの場合、刺激電極は、縦長にすると良い。これは、触覚の空間マスキングによる認識率の低下を防ぐためである。

【００５３】

図１６は、マウスポインタ５１が映像モニタ上を移動した際の刺激電極４１を示す図である。図１５と同様、刺激電極４１の黒い部分は電流を出力する部分であるが、映像モニタ５０の明度に閾値を設け、二値に分け、明度の低い部分にあたる部分を出力する。

【００５４】

図１７に、映像モニタ５０上のマウスポインタ５１の位置、刺激電極４１のチャンネル、出力する電極、刺激波形パターンについて示す。刺激にはパルス波を使用し、陽極性刺激を用いる。電気刺激のパラメータとしては、出力電流値［ｍＡ］、パルス幅［μｓｅｃ］、パルス頻度［Ｈｚ］が挙げられる。パルス幅は２００［μｓｅｃ］程度、パルス頻度は４００［Ｈｚ］程度が適当である。出力電流値については、同時に出力する刺激電極の数によって変化させる必要がある。即ち、刺激電極数が多くなれば、各電極の出力電流値は下げる必要がある。そのため、各電極の出力電流値の合計が１．５［ｍＡ］程度になるように各電極の出力電流値を制御する。ただし、１．５［ｍＡ］はあくまで目安であり、パルス幅や指先の皮膚の状態などによって変化する。

【００５５】

第２の実施の形態に係る触覚提示装置１０によると、皮膚を介した文字提示を行えることで、授業中や会議中など、携帯電話を開いてメールを読むことが難しい場面でもメールが読むことができる。

【００５６】

（第３の実施の形態）

第３の実施の形態では、触覚提示装置を用いた「ＧＵＩ操作時の触覚フィードバック」について説明する。

【００５７】

第３の実施の形態では、触覚提示装置１０がＰＣのマウスの代わりとなり、触覚情報のフィードバックを行い、ＧＵＩ操作の補助をする。操作者は、触覚提示装置１０をＰＣのマウスを持つのと同様に持ち、平らな面で動かすことで映像モニタ上のマウスポインタを操作する。映像モニタ上のアイコンを操作したり、ウィンドウを操作したりすることで、触覚提示装置に触覚情報がフィードバックされる。触覚提示装置１０が映像モニタ上のマウスポインタを動かすために、ＰＣの制御部と通信を行う必要があるが、この部分の通信方式は問わない。

【００５８】

又、触覚提示装置１０に取り付けられている光学式位置センサ１５により、触覚提示装置の位置を検出する。触覚情報のフィードバックは、アクチュエータ付きキャスター３３により発生する摩擦力を変化させることで行う。基本機能としては、以下の３つがある。

【００５９】

（機能１）アイコンやウィンドウをドラッグアンドドロップする際、アイコンやウィンドウを掴んでいる間、摩擦係数を高くする。

【００６０】

（機能２）地図の等高線など、高さ情報に合わせて、発生する力をコントロールする。

【００６１】

（機能３）マウスのポインタが他のウィンドウに入る瞬間やウィンドウの外に出る瞬間に振動覚を電気刺激により与える。

【００６２】

次に、（機能１）について、詳細に説明する。

【００６３】

触覚提示装置１０を用いてマウスのポインタを動かす場合は、触覚提示装置１０のアクチュエータ付きキャスター３３が発生する力は０である。図２０（ａ）に示すように、ア

クチュエータ３５ａ、３５ｂとキャスター３４が接触していると、アクチュエータが持っている摩擦がある。発生する力を０とするためには、発生する力を相殺するようにアクチュエータが力を発生するか、図２０（ｂ）に示すように、アクチュエータ３５ａ、３５ｂとキャスター３４の接触を解除する必要がある。アクチュエータ付きキャスター３３が発生する力が０であるならば、どちらの方法でも良い。触覚提示装置１０は、図３に示すスイッチ３１を押すことで、マウスのクリックにあたる機能が満たされる。これを用いて、触覚提示装置１０でアイコンやウィンドウをドラッグする際、アクチュエータ付きキャスター３３により摩擦力を発生する。発生する摩擦力は、第１の実施の形態と同様で、触覚提示装置１０の動作速度と指３０の押し付け力と設定摩擦係数により与えられる。設定摩擦係数は、ドラッグするアイコンやウィンドウの面積により与えられる。設定摩擦係数の指針としては、デスクトップのアイコンサイズで摩擦係数：２程度、映像ディスプレイ全体のウィンドウの面積で摩擦係数：５程度である。摩擦力の発生は、アイコンやウィンドウをドラッグしている間は常に発生する。アイコンやウィンドウをドロップした際には、アクチュエータ付きキャスター３３の発生する力は０に戻る。摩擦係数の変化とドラッグアンドドロップの関係を図１８に示す。

【００６４】

以上により、アイコンやウィンドウをドラッグしている間に、何かを持ち上げているような感覚が得られ、よりリアルなＧＵＩ操作が可能となる。

【００６５】

次に、（機能２）について、詳細に説明する。

【００６６】

機能２では、地図の等高線や天気図などの高さ情報に合わせて、アクチュエータ付きキャスター３３が発生する力をコントロールする。これを実現するには、地図や天気図などに高さ情報を入れておく必要がある。その高さ情報を元に、仮想される傾斜を求め、発生力を求める。図１９（ａ）に示す等高線が表示された映像モニタを触覚提示装置１０によってなぞる場合、図１９（ｂ）に示すように、重力加速度をｇ、触覚提示装置１０の筐体部の重さをｍとし、傾斜角をθとすると、発生力は、ｍ・ｇ・sinθとなる。傾斜角θに応じて、発生力ｍ・ｇ・sinθを出力する。この発生力は、触覚提示装置１０に指が触れているときのみ、出力する。つまり、指が触覚提示装置に振れていない状態では、発生力は０である。

【００６７】

以上により、映像ディスプレイに表現される高さ情報を実際に力として感じることが可能となり、現実感の向上に繋がる。

【００６８】

次に、（機能３）について、詳細に説明する。

【００６９】

機能３では、マウスのポインタがウィンドウの外や中に出たり入ったりする瞬間に刺激電極部１１により、電流を出力することで振動覚を与える。これを図２１に示す。触覚提示装置１０によりマウスのポインタを動かし、マウスのポインタが存在するあるウィンドウの境界を通過する瞬間に電気刺激により振動覚を再現する。電気刺激を出力する電極は、指が触れている刺激電極４１すべてのチャンネルから出力する。極性は陽極性の電流、パルス幅は２００［μｓｅｃ］、電流値はすべての電極の合計が１．８［ｍＡ］程度が良い。パルス頻度は４００［Ｈｚ］程度、パルスの数は４つ程度が適当である。しかし、出力電流値は皮膚などの状態で変化するため、上記に記した数値に制限はしない。また、パルス幅、パルス頻度、パルスの数についても同様に制限はない。

【００７０】

以上により、ウィンドウの境界を明確に知覚することが可能となる。

【００７１】

第３の実施の形態に係る触覚提示装置によると、モータにより推進力を発生可能とすることで、ＧＵＩ操作時の触覚フィードバックがより効果的なものとなる。推進力を発生す

ることで、従来では不可能であった、マウスの誘導が可能となったり、画像ディスプレイに表示された等高線に対して、傾斜を擬似的に再現可能になったりする。これらにより、ＧＵＩ操作でのより素早い操作や教育面でのよりリアルな体験などが可能になる。

【００７２】

（その他の実施形態）

本発明は上記の実施形態によって記載したが、この開示の一部をなす論述及び図面はこの発明を限定するものであると理解すべきではない。この開示から当業者には様々な代替実施形態、実施例及び運用技術が明らかとなろう。

【００７３】

例えば、本発明の実施の形態において、「布などの触り心地提示」、「皮膚を介した文字提示」、「ＧＵＩ操作時の触覚フィードバック」を実現する触覚提示装置について説明したが、振動覚と摩擦感の再現により、その他の様々な機能を満たすことができ、本発明に係る触覚提示装置は、これらの使用に限られるわけではないことは勿論である。

【００７４】

このように、本発明はここでは記載していない様々な実施形態等を含むことは勿論である。従って、本発明の技術的範囲は上記の説明から妥当な特許請求の範囲に係る発明特定事項によってのみ定められるものである。

【図面の簡単な説明】

【００７５】

【図１】第１の実施の形態に係る触覚提示装置の構成ブロック図である。

【図２】第１の実施の形態に係る触覚提示装置の外観図である。

【図３】第１の実施の形態に係る触覚提示装置の内部構造を示す図である。

【図４】第１の実施の形態に係る触覚提示装置において、再現する物体の表面形状を示す図である。

【図５】第１の実施の形態に係る触覚提示装置において、触り心地を提示する際のパラメータを説明するための図である。

【図６】第１の実施の形態に係る触覚提示装置において、電気刺激の波形を示す図である。

【図７】第１の実施の形態に係る触覚提示装置の刺激電極部の拡大図である（その１）。

【図８】第１の実施の形態に係る触覚提示装置の刺激電極部の拡大図である（その２）。

【図９】第１の実施の形態に係る触覚提示装置において、電気刺激による振動覚を説明するための図である。

【図１０】第１の実施の形態に係る触覚提示装置において、摩擦係数が$\mu 1 > \mu 0$の場合を説明するための図である。

【図１１】第１の実施の形態に係る触覚提示装置において、摩擦係数が$\mu 1 < \mu 0$の場合を説明するための図である。

【図１２】第２の実施の形態に係る触覚提示装置において、文字提示を説明するための図である。

【図１３】第２の実施の形態に係る触覚提示装置において、順次提示モードにおける電流出力パターンを示す図である。

【図１４】第２の実施の形態に係る触覚提示装置において、移動スリットモードにおける映像モニタを示す図である。

【図１５】図１４において、刺激電極部からの出力電極を示す図である。

【図１６】第２の実施の形態に係る触覚提示装置において、マウスポインタが移動した際の刺激電極部からの出力電極を示す図である。

【図１７】第２の実施の形態に係る触覚提示装置において、移動スリットモード時の各電極からの刺激パターンを示す図である。

【図１８】第３の実施の形態に係る触覚提示装置において、摩擦係数の変化とドラッグアンドドロップを示す図である。

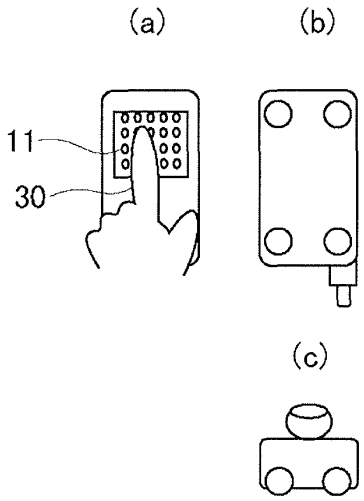
【図１９】第３の実施の形態に係る触覚提示装置において、仮想の傾斜と発生力を説明す

るための図である。
【図２０】第３の実施の形態に係る触覚提示装置において、アクチュエータ付きキャスターの動作を示す図である。
【図２１】第３の実施の形態に係る触覚提示装置において、マウスポインタの位置と電気刺激のタイミングを示す図である。
【符号の説明】
【００７６】
１０…触覚提示装置
１１…刺激電極部
１４…押圧力センサ
１５…光学式位置センサ
１６…摩擦力発生部
１７…推進力発生部
２０…電流モニタ
２１…アンプ
２２…モータドライバ
２３…Ｄ／Ａ変換器
２４…Ａ／Ｄ変換器
２５…制御部
３０…指
３１…スイッチ
３３…アクチュエータ付きキャスター
３４…キャスター
３５、３５ａ、３５ｂ…アクチュエータ
４０…不関電極
４１…刺激電極
４３…感覚受容器
４４…神経
５０…映像モニタ
５１…マウスポインタ

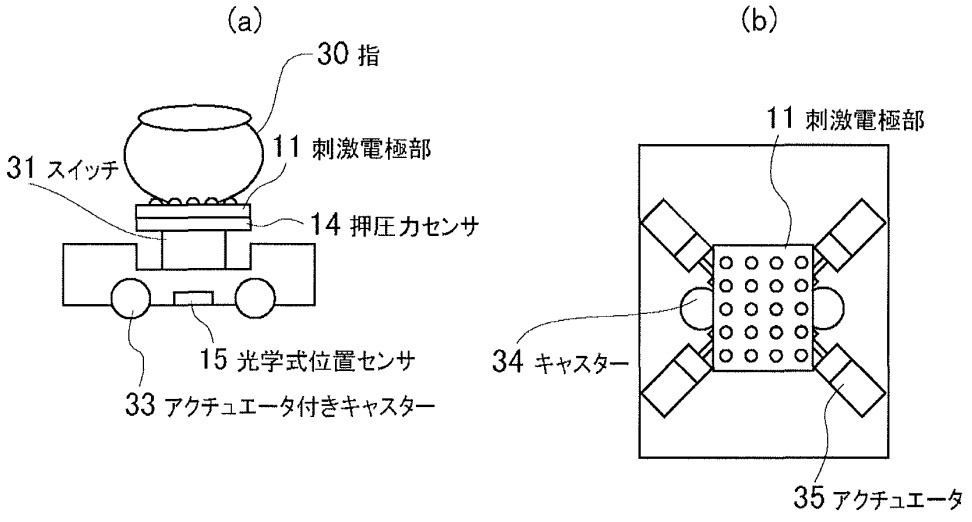
【図１】

20
10
電流モニタ
21
アンプ
23
25
D/A
刺激電極部
11
モータドライバ
制御部
16
22
摩擦力発生部
A/D
推進力発生部
24
17
14
押圧力センサ
15
光学式位置センサ

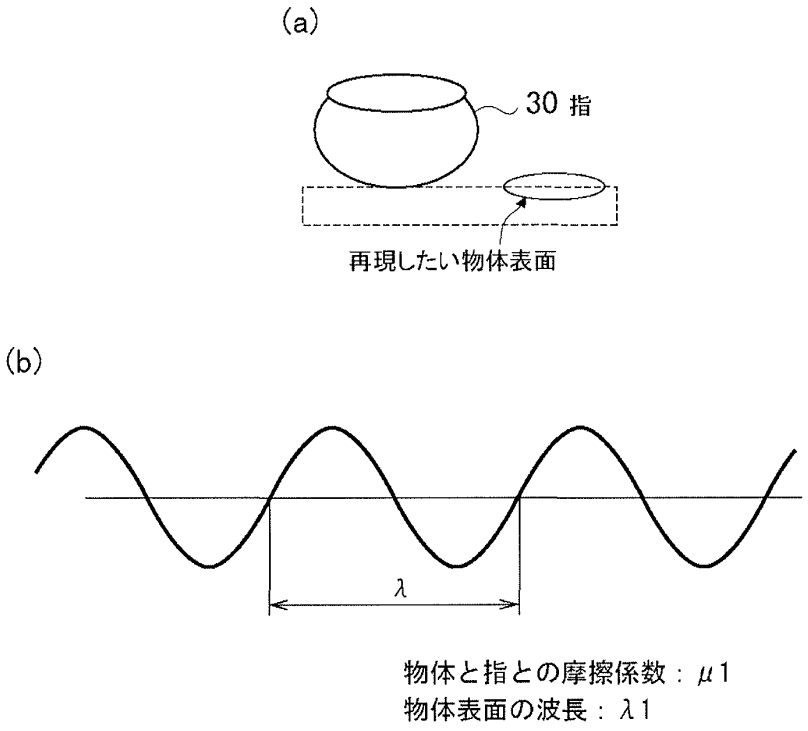
【図２】


(a)
(b)
11
30
(c)

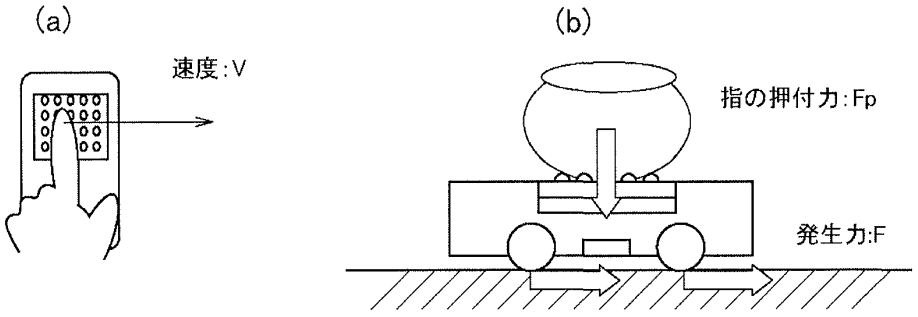
【図３】


(a)
30 指
11 刺激電極部
31 スイッチ
14 押圧力センサ
15 光学式位置センサ
33 アクチュエータ付きキャスター
(b)
11 刺激電極部
34 キャスター
35 アクチュエータ

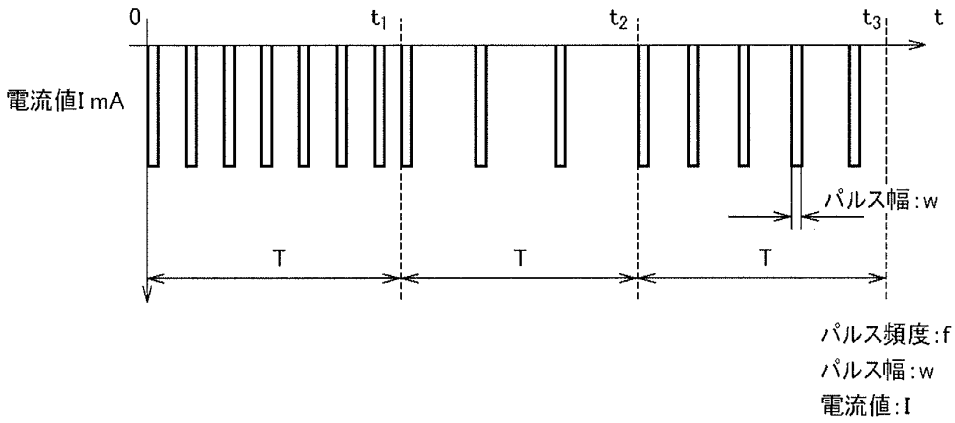
【図４】


(a)
30 指
再現したい物体表面
(b)
λ
物体と指との摩擦係数：μ1
物体表面の波長：λ1

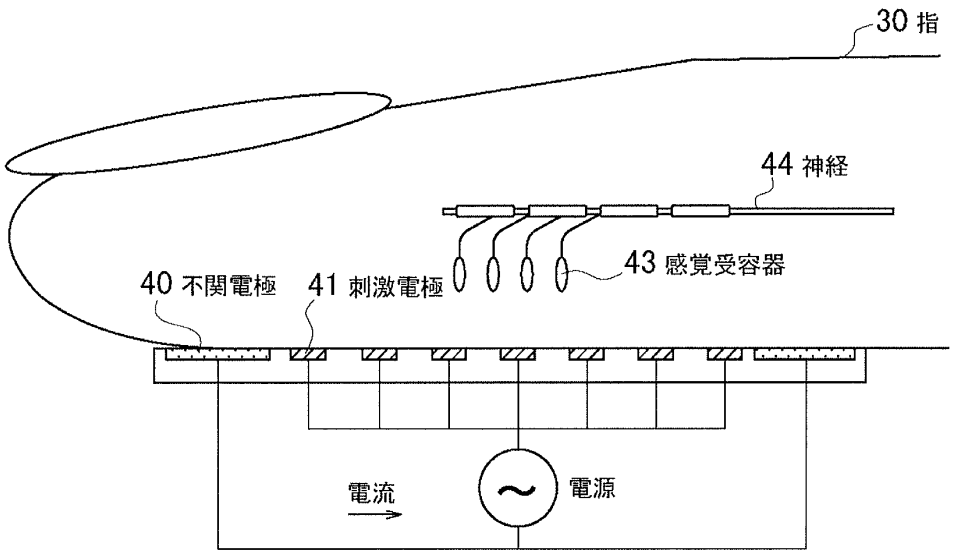
【図５】


(a)
速度:V
(b)
指の押付力:Fp
発生力:F

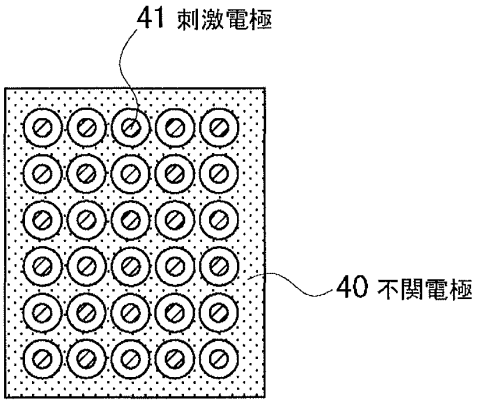
【図６】


0
t1
t2
t3
t
電流値I mA
パルス幅:w
T
T
T
パルス頻度:f
パルス幅:w
電流値:I

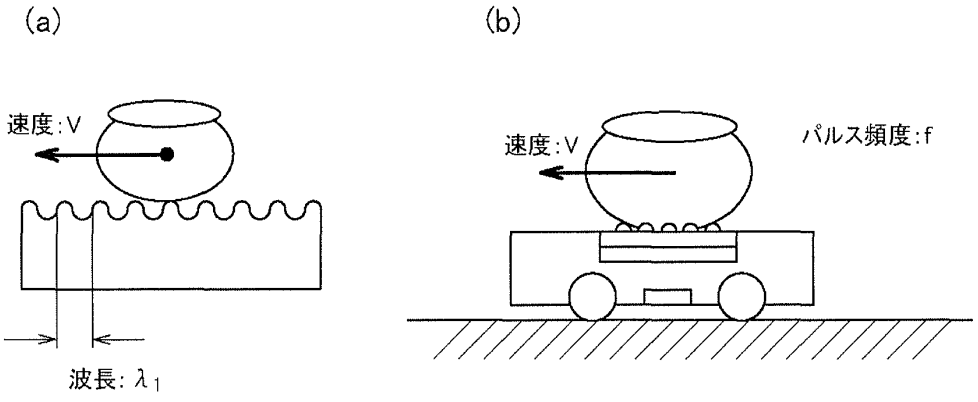
【図７】


30 指
44 神経
43 感覚受容器
40 不関電極
41 刺激電極
電流
電源

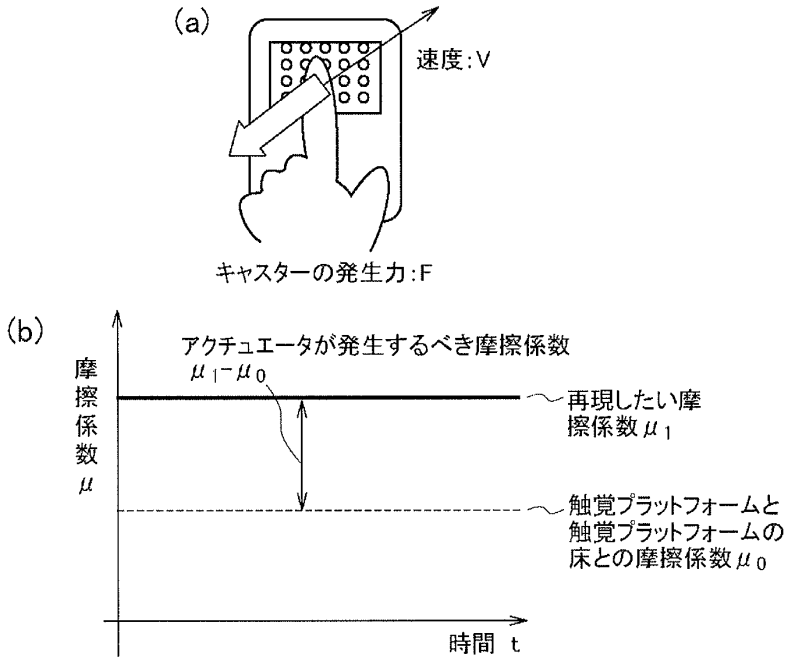
【図８】



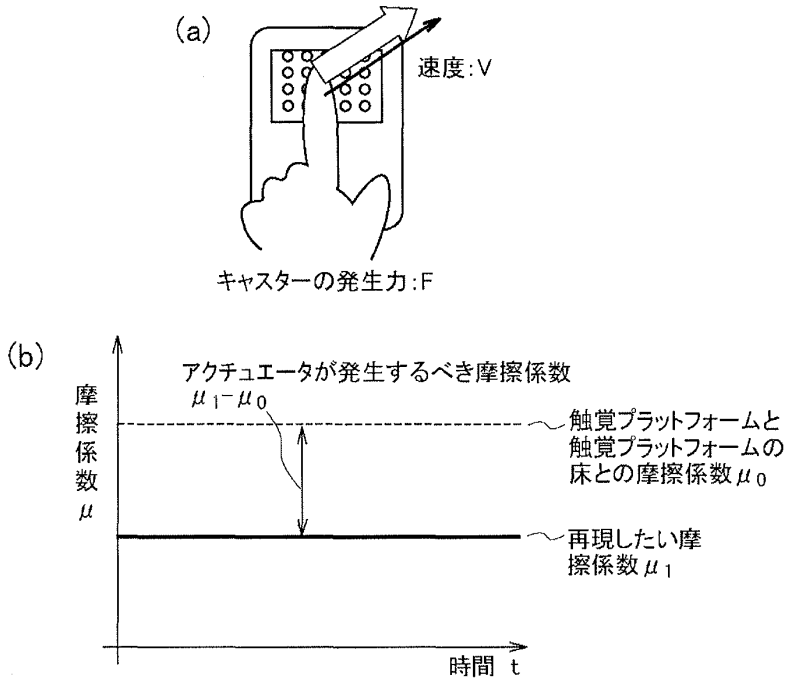
【図９】



【図１０】

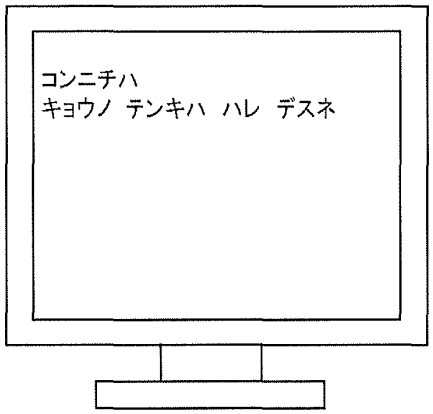

(a)
速度:V
キャスターの発生力:F
(b)
摩擦係数μ
アクチュエータが発生するべき摩擦係数
μ1−μ0
再現したい摩擦係数μ1
触覚プラットフォームと触覚プラットフォームの床との摩擦係数μ0
時間 t

【図１１】


(a)
速度:V
キャスターの発生力:F
(b)
アクチュエータが発生するべき摩擦係数
$\mu_1-\mu_0$
摩擦係数 μ
触覚プラットフォームと触覚プラットフォームの床との摩擦係数 μ_0
再現したい摩擦係数 μ_1
時間 t

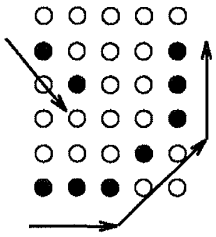
【図１２】

(a)



PCのモニタに出力された
メールの文字列

(b)

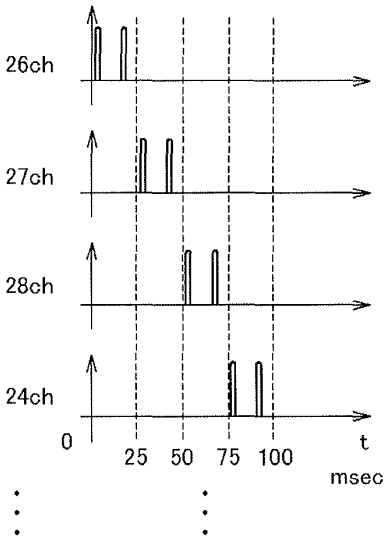


電極のチャンネル番号

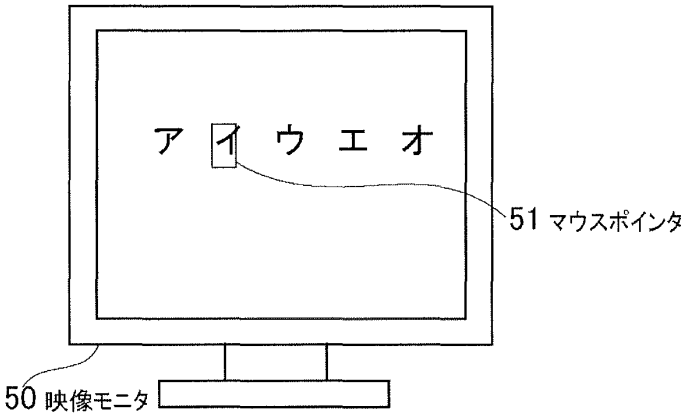
1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30

【ン】 1画目 ： 6ch→12ch
2画目 ： 26ch→27ch→28ch→24ch→20ch→15ch→10ch

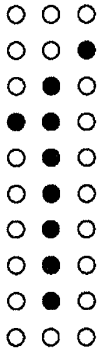
【図１３】



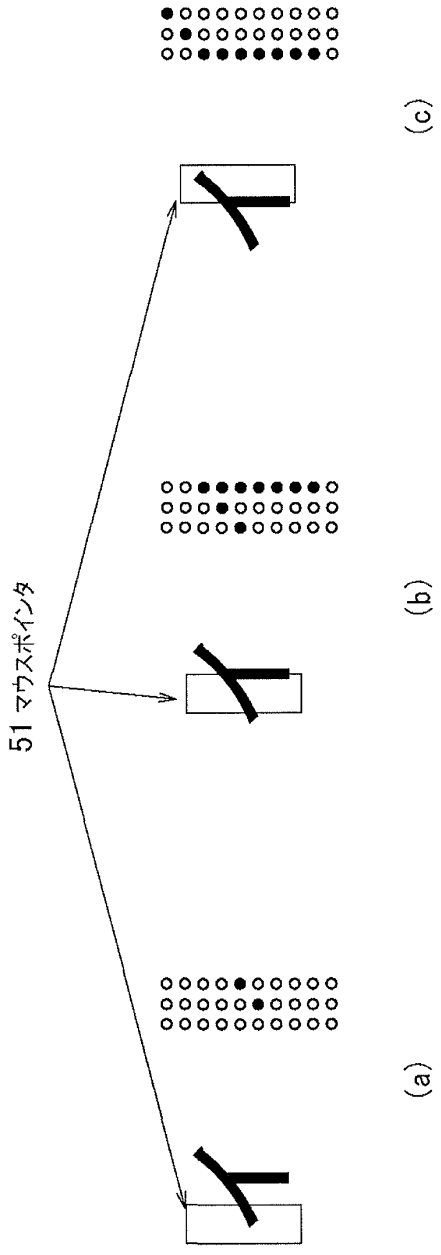
【図１４】



【図１５】

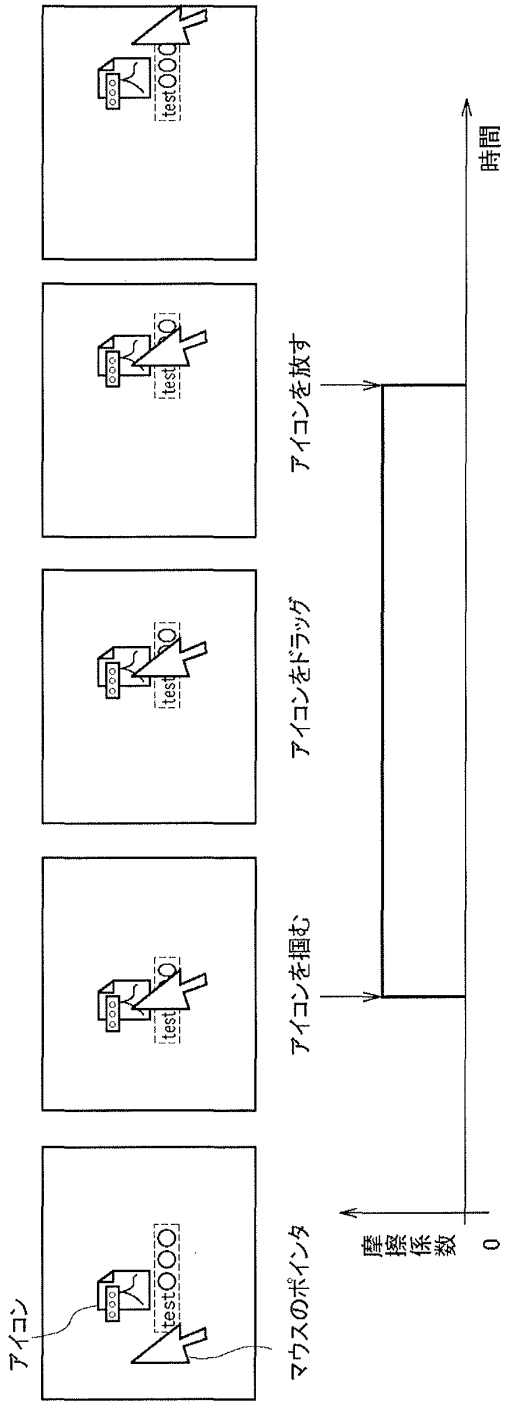


【図１６】

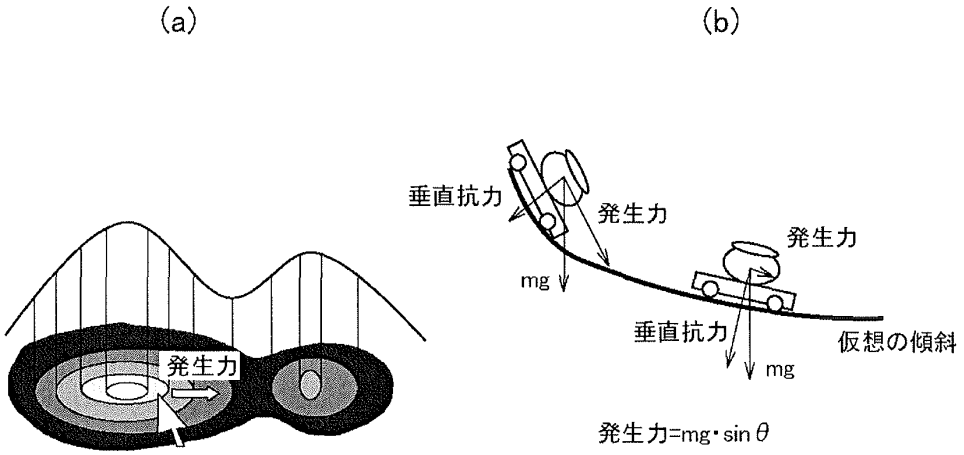


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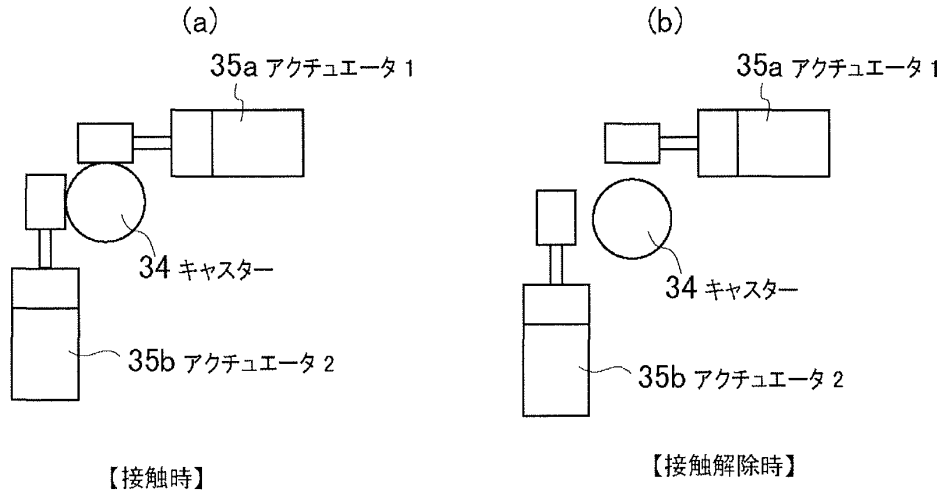
【図１８】


testOOO
test
test
test
testOOO
アイコン
マウスのポインタ
アイコンを掴む
アイコンをドラッグ
アイコンを放す
摩擦係数
0
時間

【図１９】


(a)
(b)
発生力
垂直抗力
発生力
発生力
mg
垂直抗力
mg
仮想の傾斜
発生力=mg・sinθ

【図２０】


(a)
35a アクチュエータ１
34 キャスター
35b アクチュエータ２
【接触時】
(b)
35a アクチュエータ１
34 キャスター
35b アクチュエータ２
【接触解除時】

【図２１】

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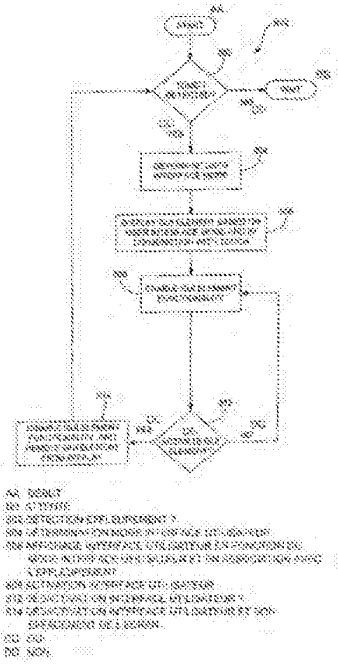
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(54) Title: MODE-BASED GRAPHICAL USER INTERFACES FOR TOUCH SENSITIVE INPUT DEVICES

(57) Abstract: A user interface method is disclosed. The method includes detecting a touch and then determining a user interface mode when a touch is detected. The method further includes activating one or more GUI elements based on the user interface mode and in response to the detected touch.



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MODE-BASED GRAPHICAL USER INTERFACES FOR TOUCH SENSITIVE INPUT DEVICES

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to gesturing associated with touch sensitive devices.

Description of the Related Art

[0002] There exist today many styles of input devices for performing operations in a computer system. The operations generally correspond to moving a cursor and making selections on a display screen. The operations may also include paging, scrolling, panning, zooming, etc. By way of example, the input devices may include buttons, switches, keyboards, mice, trackballs, touch pads, joy sticks, touch screens and the like. Each of these devices has advantages and disadvantages that are taken into account when designing the computer system.

[0003] Buttons and switches are generally mechanical in nature and provide limited control with regards to the movement of the cursor and making selections. For example, they are generally dedicated to moving the cursor in a specific direction (e.g., arrow keys) or to making specific selections (e.g., enter, delete, number, etc.).

[0004] In mice, the movement of the input pointer corresponds to the relative movements of the mouse as the user moves the mouse along a surface. In trackballs, the movement of the input pointer corresponds to the relative movements of a ball as the user moves the ball within a housing. Mice and trackballs also include one or more buttons for making selections. Mice may also include scroll wheels that allow a user to move through the GUI by simply rolling the wheel forward or backward.

[0005] With touch pads, the movement of the input pointer corresponds to the relative movements of the user's finger (or stylus) as the finger is moved along a surface of the touch pad. Touch screens, on the other hand, are a type of display screen that has a touch-sensitive transparent panel covering the screen. When using a touch screen, a user makes a selection on the display screen by pointing directly to GUI objects on the screen (usually with a stylus or finger).

[0006] In order to provide additionally functionality, gestures have been implemented with some of these input devices. By way of example, in touch pads, selections may be made when one or more taps are detected on the surface of the touch pad. In some cases, any portion of the touch pad may be tapped, and in other cases a dedicated portion of the touch pad may be tapped. In addition to selections, scrolling may be initiated by using finger motion at the edge of the touch pad.

[0007] U.S. Patent 5,612,719 and 5,590,219, assigned to Apple Computer, Inc. describe some other uses of gesturing. U.S. Patent 5,612, 719 discloses an onscreen button that is responsive to at least two different button gestures made on the screen on or near the button. U.S. Patent 5,590, 219 discloses a method for recognizing an ellipse-type gesture input on a display screen of a computer system.

[0008] In recent times, more advanced gestures have been implemented. For example, scrolling may be initiated by placing four fingers on the touch pad so that the scrolling gesture is recognized and thereafter moving these fingers on the touch pad to perform scrolling events. The methods for implementing these advanced gestures, however, has several drawbacks. By way of example, once the gesture is set, it cannot be changed until the user resets the gesture state. In touch pads, for example, if four fingers equals scrolling, and the user puts a thumb down after the four fingers are recognized, any action associated with the new gesture including four fingers and the thumb will not be performed until the entire hand is lifted off the touch pad and put back down again (e.g., reset). Simply put, the user cannot change gesture states midstream. Along a similar vein, only one gesture may be performed at any given time. That is, multiple gestures cannot be performed simultaneously.

[0009] Based on the above, there is a need for improvements in the way gestures are performed on touch sensitive devices.

SUMMARY OF THE INVENTION

[0010] The invention pertains to gestures and methods of implementing gestures with touch sensitive devices. Examples of touch sensitive devices include touch screens and touch pads. The invention also pertains to user interfaces and methods of implementing user interfaces with displays.

[0011] The invention can be implemented in numerous ways, including as a method, graphical user interface, computing device, or a computer readable medium. Several embodiments of the invention are discussed below.

[0012] The invention relates, in one embodiment, to a user interface method. The method includes detecting a touch. The method also includes determining a user interface mode when a touch is detected. The method further includes activating one or more GUI elements based on the user interface mode and in response to the detected touch.

[0013] The invention relates, in one embodiment, to a user interface method. The method includes displaying a group of media items. The method also includes detecting a touch over the group of media items that are displayed. The method further includes activating a virtual scroll wheel when a touch is detected over the displayed media items. The activation of the virtual scroll wheel includes displaying and enabling the functionality of the virtual scroll wheel, the virtual scroll wheel providing a touch region where a user swirls their finger in order to traverse through the group of media items. The method additionally includes determining if a touch event is performed relative to the touch region of the virtual scroll wheel. Moreover, the method includes scrolling through the group of media items when a scrolling touch event is performed.

[0014] The invention relates, in one embodiment, to a method performed on a user operated electronic device having a display and a touch screen. The method includes determining if a touch is detected. The method also includes monitoring and analyzing the current operating conditions when a touch is detected. The method also includes activating a first GUI element for a first set of operating conditions. The method additionally includes activating a second GUI element for a second set of operating conditions.

[0015] The invention relates, in one embodiment, to a method performed on a computing device having a display and a touch sensing input device. The method includes sensing touches. The method also includes displaying and enabling a GUI element when a touch is detected. The GUI element is based on at least one of the following:(a) the application currently running on the computing device; (b) the current state of the application; and/or (c) one or more characteristics of the touch. The characteristics include, for example, touch location, touch ID, number of touches, and touch motion. The method further includes disabling and removing the GUI element from display when one of the following events occurs: (a) the touch is no longer detected, (b) a touch has not been detected for a preset amount of time, (c) a

certain amount of time has gone by since the step of displaying and enabling, (d) a user selection.

[0016] The invention relates, in another embodiment, to a computing system. The computing system includes a display device configured to display a graphical user interface. The system also includes a touch screen positioned over the display device. The touch screen is configured to detect touches that occur over the display device. The system further includes a processor operatively coupled to the display device and the touch screen. The processor instructs the display device to display one or more GUI elements in response to a touch, and performs actions associated with the GUI element when touch events are detected relative to the displayed GUI elements.

[0017] The invention relates, in another embodiment, to a computing device. The computing device includes a processor. The computing device also includes a touch screen capable of sensing touch events. The computing device further includes a display configured to simultaneously display a plurality of media items and a virtual scroll wheel. The virtual scroll wheel provides a region where touch events are performed in order to implement a scrolling action. The scrolling action allows a user to traverse through the plurality of media items.

[0018] Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

Fig. 1 is a block diagram of a computer system, in accordance with one embodiment of the present invention.

Fig. 2 is a multipoint processing method, in accordance with one embodiment of the present invention.

Figs. 3A and B illustrate an image, in accordance with one embodiment of the present invention.

Fig. 4 illustrates a group of features, in accordance with one embodiment of the present invention.

Fig. 5 is a parameter calculation method, in accordance with one embodiment of the present invention.

Figs. 6A-6G illustrate a rotate gesture, in accordance with one embodiment of the present invention.

Fig. 7 is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

Fig. 8 is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

Fig. 9 is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

Fig. 10 is a diagram of a zoom gesture method, in accordance with one embodiment of the present invention.

Figs. 11A-11H illustrates a zooming sequence, in accordance with one embodiment of the present invention.

Fig. 12 is a diagram of a pan method, in accordance with one embodiment of the present invention.

Figs. 13A-13D illustrate a panning sequence, in accordance with one embodiment of the present invention.

Fig. 14 is a diagram of a rotate method, in accordance with one embodiment of the present invention.

Figs. 15A-15C illustrate a rotating sequence, in accordance with one embodiment of the present invention.

Fig. 16 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 17A-17E illustrate a floating control sequence, in accordance with one embodiment of the present invention.

Fig. 18 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 19A-19D illustrate a zooming target sequence, in accordance with one embodiment of the present invention.

Fig. 20 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 21A-21D illustrate a page turning sequence, in accordance with one embodiment of the present invention.

Fig. 22 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 23A-23D illustrate an inertia sequence, in accordance with one embodiment of the present invention.

Fig. 24 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 25A-25D illustrates a keyboard sequence, in accordance with one embodiment of the present invention.

Fig. 26 is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

Figs. 27A-27D illustrates a scroll wheel sequence, in accordance with one embodiment of the present invention.

Fig. 28 is user interface method, in accordance with one embodiment of the present invention.

Figs. 29A-29D illustrate a transition effect, in accordance with one embodiment of the present invention.

Figs. 30A-30D illustrate a transition effect, in accordance with another embodiment of the present invention.

Figs. 31A-31D illustrate a transition effect, in accordance with another embodiment of the present invention.

Fig. 32 is a determination method, in accordance with one embodiment of the present invention.

Fig. 33 is a user interface method, in accordance with one embodiment of the present invention.

Fig. 34A-34F illustrates a sequence associated with the method shown in Fig. 33, in accordance with one embodiment of the present invention.

Fig. 35A-35F illustrates a sequence associated with the method shown in Fig. 33, in accordance with one embodiment of the present invention.

Figs. 36A-36C illustrate a user interface sequence, in accordance with one embodiment of the present invention.

Fig. 37 is a user interface method, in accordance with one embodiment of the present invention

Figs. 38A-38J illustrate a user interface sequence, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The invention pertains to gestures and methods of implementing gestures with touch sensitive devices. Examples of touch sensitive devices include touch screens and touch pads. The invention also pertains to user interfaces and methods of implementing user interfaces with displays. One aspect of the invention relates to determining a user interface mode based on one or more conditions. Another aspect of the invention relates to activating one or more GUI elements based on the user interface mode (e.g., displaying a GUI element). Another aspect of the invention relates to a virtual scroll wheel.

[0020] These and other aspects of the invention are discussed below with reference to Figs. 1-38J. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

[0021] Fig. 1 is a block diagram of an exemplary computer system 50, in accordance with one embodiment of the present invention. The computer system 50 may correspond to a personal computer system, such as a desktops, laptops, tablets or handheld computer. The computer system may also correspond to a computing device, such as a cell phone, PDA, dedicated media player, consumer electronic device, and the like.

[0022] The exemplary computer system 50 shown in Fig. 1 includes a processor 56 configured to execute instructions and to carry out operations associated with the computer system 50. For example, using instructions retrieved for example from memory, the processor 56 may control the reception and manipulation of input and output data between components of the computing system 50. The processor 56 can be implemented on a single-chip, multiple chips or multiple electrical components. For example, various architectures can be used for the processor 56, including dedicated or embedded processor, single purpose processor, controller, ASIC, and so forth.

[0023] In most cases, the processor 56 together with an operating system operates to execute computer code and produce and use data. Operating systems are generally well known and will not be described in greater detail. By way of example, the operating system may correspond to OS/2, DOS, Unix, Linux, Palm OS, and the like. The operating system can also be a special purpose operating system, such as may be used for limited purpose appliance-type computing devices. The operating system,

other computer code and data may reside within a memory block 58 that is operatively coupled to the processor 56. Memory block 58 generally provides a place to store computer code and data that are used by the computer system 50. By way of example, the memory block 58 may include Read-Only Memory (ROM), Random-Access Memory (RAM), hard disk drive and/or the like. The information could also reside on a removable storage medium and loaded or installed onto the computer system 50 when needed. Removable storage mediums include, for example, CD-ROM, PC-CARD, memory card, floppy disk, magnetic tape, and a network component.

[0024] The computer system 50 also includes a display device 68 that is operatively coupled to the processor 56. The display device 68 may be a liquid crystal display (LCD) (e.g., active matrix, passive matrix and the like). Alternatively, the display device 68 may be a monitor such as a monochrome display, color graphics adapter (CGA) display, enhanced graphics adapter (EGA) display, variable-graphics-array (VGA) display, super VGA display, cathode ray tube (CRT), and the like. The display device may also correspond to a plasma display or a display implemented with electronic inks.

[0025] The display device 68 is generally configured to display a graphical user interface (GUI) 69 that provides an easy to use interface between a user of the computer system and the operating system or application running thereon. Generally speaking, the GUI 69 represents, programs, files and operational options with graphical images. The graphical images may include windows, fields, dialog boxes, menus, icons, buttons, cursors, scroll bars, etc. Such images may be arranged in predefined layouts, or may be created dynamically to serve the specific actions being taken by a user. During operation, the user can select and activate various graphical images in order to initiate functions and tasks associated therewith. By way of example, a user may select a button that opens, closes, minimizes, or maximizes a window, or an icon that launches a particular program. The GUI 69 can additionally or alternatively display information, such as non interactive text and graphics, for the user on the display device 68.

[0026] The computer system 50 also includes an input device 70 that is operatively coupled to the processor 56. The input device 70 is configured to transfer data from the outside world into the computer system 50. The input device 70 may for example be used to perform tracking and to make selections with respect to the GUI 69 on the

display 68. The input device 70 may also be used to issue commands in the computer system 50. The input device 70 may include a touch sensing device configured to receive input from a user's touch and to send this information to the processor 56. By way of example, the touch-sensing device may correspond to a touchpad or a touch screen. In many cases, the touch-sensing device recognizes touches, as well as the position and magnitude of touches on a touch sensitive surface. The touch sensing means reports the touches to the processor 56 and the processor 56 interprets the touches in accordance with its programming. For example, the processor 56 may initiate a task in accordance with a particular touch. A dedicated processor can be used to process touches locally and reduce demand for the main processor of the computer system. The touch sensing device may be based on sensing technologies including but not limited to capacitive sensing, resistive sensing, surface acoustic wave sensing, pressure sensing, optical sensing, and/or the like. Furthermore, the touch sensing means may be based on single point sensing or multipoint sensing. Single point sensing is capable of only distinguishing a single touch, while multipoint sensing is capable of distinguishing multiple touches that occur at the same time.

[0027] The input device 70 may be a touch screen that is positioned over or in front of the display 68. The touch screen 70 may be integrated with the display device 68 or it may be a separate component. The touch screen 70 has several advantages over other input technologies such as touchpads, mice, etc. For one, the touch screen 70 is positioned in front of the display 68 and therefore the user can manipulate the GUI 69 directly. For example, the user can simply place their finger over an object to be controlled. In touch pads, there is no one–to-one relationship such as this. With touchpads, the touchpad is placed away from the display typically in a different plane. For example, the display is typically located in a vertical plane and the touchpad is typically located in a horizontal plane. This makes its use less intuitive, and therefore more difficult when compared to touch screens. In addition to being a touch screen, the input device 70 can be a multipoint input device. Multipoint input devices have advantages over conventional singlepoint devices in that they can distinguish more than one object (finger). Singlepoint devices are simply incapable of distinguishing multiple objects. By way of example, a multipoint touch screen, which can be used herein, is shown and described in greater detail in copending and commonly assigned U.S. Patent Application No.: 10/840,862, which is hereby incorporated herein by reference.

[0028] The computer system 50 also includes capabilities for coupling to one or more I/O devices 80. By way of example, the I/O devices 80 may correspond to keyboards, printers, scanners, cameras, speakers, and/or the like. The I/O devices 80 may be integrated with the computer system 50 or they may be separate components (e.g., peripheral devices). In some cases, the I/O devices 80 may be connected to the computer system 50 through wired connections (e.g., cables/ports). In other cases, the I/O devices 80 may be connected to the computer system 80 through wireless connections. By way of example, the data link may correspond to PS/2, USB, IR, RF, Bluetooth or the like.

[0029] In accordance with one embodiment of the present invention, the computer system 50 is designed to recognize gestures 85 applied to the input device 70 and to control aspects of the computer system 50 based on the gestures 85. In some cases, a gesture is defined as a stylized interaction with an input device that is mapped to one or more specific computing operations. The gestures 85 may be made through various hand, and more particularly finger motions. Alternatively or additionally, the gestures may be made with a stylus. In all of these cases, the input device 70 receives the gestures 85 and the processor 56 executes instructions to carry out operations associated with the gestures 85. In addition, the memory block 58 may include a gesture operational program 88, which may be part of the operating system or a separate application. The gestural operation program 88 generally includes a set of instructions that recognizes the occurrence of gestures 85 and informs one or more software agents of the gestures 85 and/or what action(s) to take in response to the gestures 85.

[0030] When a user performs one or more gestures, the input device 70 relays gesture information to the processor 56. Using instructions from memory 58, and more particularly, the gestural operational program 88, the processor 56 interprets the gestures 85 and controls different components of the computer system 50, such as memory 58, a display 68 and I/O devices 80, based on the gestures 85. The gestures 85 may be identified as commands for performing actions in applications stored in the memory 58, modifying GUI objects shown on the display 68, modifying data stored in memory 58, and/or for performing actions in I/O devices 80. By way of example, the commands may be associated with zooming, panning, scrolling, paging, rotating, sizing, and the like. As further examples, the commands may also be associated with launching a particular program, opening a file or document, viewing a menu, making

a selection, executing instructions, logging onto the computer system, permitting authorized individuals access to restricted areas of the computer system, loading a user profile associated with a user's preferred arrangement of the computer desktop, and/or the like.

[0031] A wide range of different gestures can be utilized. By way of example, the gestures may be single point or multipoint gestures; static or dynamic gestures; continuous or segmented gestures; and/or the like. Single point gestures are those gestures that are performed with a single contact point, e.g., the gesture is performed with a single touch as for example from a single finger, a palm or a stylus. Multipoint gestures are those gestures that can be performed with multiple points, e.g., the gesture is performed with multiple touches as for example from multiple fingers, fingers and palms, a finger and a stylus, multiple styli and/or any combination thereof. Static gestures are those gestures that do not include motion, and dynamic gestures are those gestures that do include motion. Continuous gestures are those gestures that are performed in a single stroke, and segmented gestures are those gestures that are performed in a sequence of distinct steps or strokes.

[0032] In one embodiment, the computer system 50 is configured to register multiple gestures at the same time, i.e., multiple gestures can be performed simultaneously. By way of example, a zoom gesture may be performed at the same time as a rotate gesture, or a rotate gesture may be performed at the same time as a pan gesture. In one particular implementation, zoom, rotate and pan gestures can all occur simultaneously in order to perform zooming, rotating and panning at the same time.

[0033] In another embodiment, the system is configured to immediately recognize the gestures so that actions associated with the gestures can be implemented at the same time as the gesture, i.e., the gesture and action simultaneously occur side by side rather than being a two-step process. By way of example, during a scrolling gesture, the screen moves with the finger motion.

[0034] In another embodiment, an object presented on a display 68 continuously follows the gesture occurring on a touch screen. There is a one to one relationship between the gesture being performed and the objects shown on the display 68. For example, as the gesture is performed, modifications simultaneously occur to the objects located underneath the gesture. For example, during a zooming gesture, the fingers may spread apart or close together in order to cause the object shown on the display 68 to zoom in during the spreading and zoom out during the closing. During

this operation, the computer system 50 recognizes the user input as a zoom gesture, determines what action should be taken, and outputs control data to the appropriate device, in this case the display 68.

[0035] In another embodiment, the computer system 50 provides region sensitivity where gestures mean different things when implemented over different areas of the input device 68. For example, a rotation gesture over a volume knob causes volume increase/decrease, whereas a rotation gesture over a photo causes rotation of the photo.

[0036] In another embodiment, the number of fingers in contact with the touch screen may indicate an input mode. For example, a single touch as for example by a single finger may indicate the desire to perform tracking, i.e., pointer or cursor movements, or selections, whereas multiple touches as for example by a group of fingers may indicate the desire to perform gesturing. The number of fingers for implementing gesturing may be widely varied. By way of example, two fingers may indicate a first gesture mode, three fingers may indicate a third gesture mode, etc. Alternatively, any number of fingers, i.e., more than one, may be used for the same gesture mode, which can include one ore more gesture controls. The orientation of the fingers may similarly be used to denote the desired mode. The profile of the finger may be detected to permit different modal operations based on whether the user has used his thumb or index finger, for example.

[0037] In another embodiment, an input can be changed while making a continuous stroke on the input device without stopping the stroke (e.g., lifting off the touch sensitive surface). In one implementation, the user can switch from a tracking (or selection) mode to gesturing mode while a stroke is being made. For example, tracking or selections may be associated with a single finger and gesturing may be associated with multiple fingers; therefore, the user can toggle between tracking/selection and gesturing by picking up and placing down a second finger on the touch screen. In another implementation, the user can switch from one gesture mode to another gesture mode while a stroke is being made. For example, zooming may be associated with spreading a pair of fingers and rotating may be associated with rotating the pair of fingers; therefore, the user can toggle between zooming and rotating by alternating the movement of their fingers between spreading and rotating. In yet another implementation, the number of gesture inputs can be changed while a stroke is being made (e.g., added or subtracted). For example, during zooming where

the fingers are spread apart, the user may further rotate their fingers to initiate both zooming and rotation. Furthermore during zooming and rotation, the user can stop spreading their fingers so that only rotation occurs. In other words, the gesture inputs can be continuously input, either simultaneously or consecutively.

[0038] In one particular embodiment, a single finger initiates tracking (or selection) and two or more fingers in close proximity to one another initiates scrolling or panning. Two fingers is generally preferred so as to provide easy toggling between one and two fingers, i.e., the user can switch between modes very easily by simply picking or placing an additional finger. This has the advantage of being more intuitive than other forms of mode toggling. During tracking, cursor movement is controlled by the user moving a single finger on the touch sensitive surface of a touch sensing device. The sensor arrangement of the touch sensing device interprets the finger motion and generates signals for producing corresponding movement of the cursor on the display. During scrolling, screen movement is controlled by the user moving dual fingers on the touch sensitive surface of the touch sensing device. When the combined fingers are moved in the vertical direction, the motion is interpreted as a vertical scroll event, and when the combined fingers are moved in the horizontal direction, the motion is interpreted as a horizontal scroll event. The same can be said for panning although panning can occur in all directions rather than just the horizontal and vertical directions.

[0039] The term "scrolling" as used herein generally pertains to moving displayed data or images (e.g., text or graphics) across a viewing area on a display screen so that a new set of data (e.g., line of text or graphics) is brought into view in the viewing area. In most cases, once the viewing area is full, each new set of data appears at the edge of the viewing area and all other sets of data move over one position. That is, the new set of data appears for each set of data that moves out of the viewing area. In essence, the scrolling function allows a user to view consecutive sets of data currently outside of the viewing area. The viewing area may be the entire viewing area of the display screen or it may only be a portion of the display screen (e.g., a window frame).

[0040] As mentioned above, scrolling may be implemented vertically (up or down) or horizontally (left or right). In the case of vertical scrolling, when a user scrolls down, each new set of data appears at the bottom of the viewing area and all other sets of data move up one position. If the viewing area is full, the top set of data moves out of

the viewing area. Similarly, when a user scrolls up, each new set of data appears at the top of the viewing area and all other sets of data move down one position. If the viewing area is full, the bottom set of data moves out of the viewing area.

[0041] By way of example, the display screen, during operation, may display a list of media items (e.g., songs). A user is able to linearly scroll through the list of media items by moving his or her finger across a touch screen. As the finger moves across the touch screen, the displayed items from the list of media items are varied such that the user is able to effectively scroll through the list of media items. In most cases, the user is able to accelerate their traversal of the list of media items by moving his or her finger at greater speeds. Some embodiments, which may be related to the above example, are described in greater detail below. See for example Figs. 6, 23, 27.

[0042] Fig. 2 is a multipoint processing method 100, in accordance with one embodiment of the present invention. The multipoint processing method 100 may for example be performed in the system shown in Fig. 1. The multipoint processing method 100 generally begins at block 102 where images are read from a multipoint input device, and more particularly a multipoint touch screen. By way of example, the multipoint touch screen may generally correspond to the multipoint touch screen disclosed in copending U.S. Patent Application No.: 10/840,862, which is hereby incorporated herein by reference. Although the term "image" is used it should be noted that the data may come in other forms. In most cases, the image read from the touch screen provides magnitude (Z) as a function of position (x and y) for each sensing point or pixel of the touch screen. The magnitude may, for example, be reflect the capacitance measured at each point.

[0043] Following block 102, multipoint processing method 100 proceeds to block 104 where the image is converted into a collection or list of features. Each feature represents a distinct input such as a touch. In most cases, each feature includes its own unique identifier (ID), x coordinate, y coordinate, Z magnitude, angle θ, area A, and the like. By way of example, Figs. 3A and 3B illustrate a particular image 120 in time. In image 120, there are two features 122 based on two distinct touches. The touches may for example be formed from a pair of fingers touching the touch screen. As shown, each feature 122 includes unique identifier (ID), x coordinate, y coordinate, Z magnitude, angle θ, and area A. More particularly, the first feature 122A is represented by ID_1, x_1, y_1, Z_1, θ_1, A_1 and the second feature 122B is

represented by ID_2, x_2, y_2, Z_2, θ_2, A_2. This data may be outputted for example using a multitouch protocol.

[0044] The conversion from data or images to features may be accomplished using methods described in copending U.S. Patent Application No.: 10/840,862 which is hereby incorporated herein by reference. As disclosed therein, the raw data is received. The raw data is typically in a digitized form, and includes values for each node of the touch screen. The values may be between 0 and 256 where 0 equates to no touch pressure and 256 equates to full touch pressure. Thereafter, the raw data is filtered to reduce noise. Once filtered, gradient data, which indicates the topology of each group of connected points, is generated. Thereafter, the boundaries for touch regions are calculated based on the gradient data, i.e., a determination is made as to which points are grouped together to form each touch region. By way of example, a watershed algorithm may be used. Once the boundaries are determined, the data for each of the touch regions are calculated (e.g., x, y, Z, θ, A).

[0045] Following block 104, multipoint processing method 100 proceeds to block 106 where feature classification and groupings are performed. During classification, the identity of each of the features is determined. For example, the features may be classified as a particular finger, thumb, palm or other object. Once classified, the features may be grouped. The manner in which the groups are formed can widely varied. In most cases, the features are grouped based on some criteria (e.g., they carry a similar attribute). For example, the two features shown in Figs. 3A and 3B may be grouped together because each of these features is located in proximity to each other or because they are from the same hand. The grouping may include some level of filtering to filter out features that are not part of the touch event. In filtering, one or more features may be rejected because they either meet some predefined criteria or because they do not meet some criteria. By way of example, one of the features may be classified as a thumb located at the edge of a tablet PC. Because the thumb is being used to hold the device rather than being used to perform a task, the feature generated therefrom is rejected, i.e., is not considered part of the touch event being processed.

[0046] Following block 106, the multipoint processing method 100 proceeds to block 108 where key parameters for the feature groups are calculated. The key parameters may include distance between features, x/y centroid of all features, feature rotation, total pressure of the group (e.g., pressure at centroid), and the like. As shown in Fig.

4, the calculation may include finding the centroid C, drawing a virtual line 130 to each feature from the centroid C, defining the distance D for each virtual line (D_1 and D_2), and then averaging the distances D_1 and D_2. Once the parameters are calculated, the parameter values are reported. The parameter values are typically reported with a group identifier (GID) and number of features within each group (in this case three). In most cases, both initial and current parameter values are reported. The initial parameter values may be based on set down, i.e., when the user sets their fingers on the touch screen, and the current values may be based on any point within a stroke occurring after set down. As should be appreciated, blocks 102-108 are repetitively performed during a user stroke thereby generating a plurality of sequentially configured signals. The initial and current parameters can be compared in later steps to perform actions in the system.

[0047] Following block 108, the process flow proceeds to block 110 where the group is or associated to a user interface (UI) element. UI elements are buttons boxes, lists, sliders, wheels, knobs, etc. Each UI element represents a component or control of the user interface. The application behind the UI element(s) has access to the parameter data calculated in block 108. In one implementation, the application ranks the relevance of the touch data to the UI element corresponding there to. The ranking may be based on some predetermine criteria. The ranking may include producing a figure of merit, and whichever UI element has the highest figure of merit, giving it sole access to the group. There may even be some degree of hysteresis as well (once one of the UI elements claims control of that group, the group sticks with the UI element until another UI element has a much higher ranking). By way of example, the ranking may include determining proximity of the centroid (or features) to the GUI object associated with the UI element.

[0048] Following block 110, the multipoint processing method 100 proceeds to blocks 112 and 114. The blocks 112 and 114 can be performed approximately at the same time. From the user perspective, in one embodiment, the blocks 112 and 114 appear to be performed concurrently. In block 112, one or more actions are performed based on differences between initial and current parameter values as well as the UI element to which they are associated. In block 114, user feedback pertaining to the one ore more action being performed is provided. By way of example, user feedback may include display, audio, tactile feedback and/or the like.

[0049] Fig. 5 is a parameter calculation method 150, in accordance with one embodiment of the present invention. The parameter calculation method 150 may, for example, correspond to block 108 shown in Fig. 2. The parameter calculation method 150 generally begins at block 152 where a group of features is received. Following block 152, the parameter calculation method 150 proceeds to block 154 where a determination is made as to whether or not the number of features in the group of features has changed. For example, the number of features may have changed due to the user picking up or placing an additional finger. Different fingers may be needed to perform different controls (e.g., tracking, gesturing). If the number of features has changed, the parameter calculation method 150 proceeds to block 156 where the initial parameter values are calculated. If the number stays the same, the parameter calculation method 150 proceeds to block 158 where the current parameter values are calculated. Thereafter, the parameter calculation method 150 proceeds to block 150 where the initial and current parameter values are reported. By way of example, the initial parameter values may contain the average initial distance between points (or Distance (AVG) initial) and the current parameter values may contain the average current distance between points (or Distance (AVG) current). These may be compared in subsequent steps in order to control various aspects of a computer system.

[0050] The above methods and techniques can be used to implement any number of GUI interface objects and actions. For example, gestures can be created to detect and effect a user command to resize a window, scroll a display, rotate an object, zoom in or out of a displayed view, delete or insert text or other objects, etc. Gestures can also be used to invoke and manipulate virtual control interfaces, such as volume knobs, switches, sliders, handles, knobs, doors, and other widgets that may be created to facilitate human interaction with the computing system.

[0051] To cite an example using the above methodologies, and referring to Figs. 6A-6G, a rotate gesture for controlling a virtual volume knob 170 on a GUI interface 172 of a display 174 of a tablet PC 175 will be described. In order to actuate the knob 170, the user places their fingers 176 on a multipoint touch screen 178. The virtual control knob may already be displayed, or the particular number, orientation or profile of the fingers at set down, or the movement of the fingers immediately thereafter, or some combination of these and other characteristics of the user's interaction may invoke the virtual control knob to be displayed. In either case, the

computing system associates a finger group to the virtual control knob and makes a determination that the user intends to use the virtual volume knob. This association may also be based in part on the mode or current state of the computing device at the time of the input. For example, the same gesture may be interpreted alternatively as a volume know gesture if a song is currently playing on the computing device, or as a rotate command if an object editing application is being executed. Other user feedback may be provided, including for example audible or tactile feedback.

[0052] Once knob 170 is displayed as shown in Fig. 6A, the user's fingers 176 can be positioned around the knob 170 similar to if it were an actual knob or dial, and thereafter can be rotated around the knob 170 in order to simulate turning the knob 170. Again, audible feedback in the form of a clicking sound or tactile feedback in the form of vibration, for example, may be provided as the knob 170 is "rotated." The user may also use their other hand to hold the tablet PC 175.

[0053] As shown in Fig. 6B, the multipoint touch screen 178 detects at least a pair of images. In particular, a first image 180 is created at set down, and at least one other image 182 is created when the fingers 176 are rotated. Although only two images are shown, in most cases there would be many more images that incrementally occur between these two images. Each image represents a profile of the fingers in contact with the touch screen at a particular instant in time. These images can also be referred to as touch images. It will be understood that the term "image" does not mean that the profile is displayed on the screen 178 (but rather imaged by the touch sensing device). It should also be noted that although the term "image" is used, the data may be in other forms representative of the touch plane at various times.

[0054] As shown in Fig. 6C, each of the images 180 and 182 is converted to a collection of features 184. Each feature 184 is associated with a particular touch as for example from the tips each of the fingers 176 surrounding the knob 170 as well as the thumb of the other hand 177 used to hold the tablet PC 175.

[0055] As shown in Fig. 6D, the features 184 are classified, i.e., each finger/thumb is identified, and grouped for each of the images 180 and 182. In this particular case, the features 184A associated with the knob 170 are grouped together to form group 188 and the feature 184B associated with the thumb is filtered out. In alternative arrangements, the thumb feature 184B may be treated as a separate feature by itself (or in another group), for example, to alter the input or operational mode of the

system or to implement another gesture, for example, a slider gesture associated with an equalizer slider displayed on the screen in the area of the thumb (or other finger).

[0056] As shown in Fig. 6E, the key parameters of the feature group 188 are calculated for each image 180 and 182. The key parameters associated with the first image 180 represent the initial state and the key parameters of the second image 182 represent the current state.

[0057] Also as shown in Fig. 6E, the knob 170 is the UI element associated with the feature group 188 because of its proximity to the knob 170. Thereafter, as shown in Fig. 6F, the key parameter values of the feature group 188 from each image 180 and 182 are compared to determine the rotation vector, i.e., the group of features rotated five (5) degrees clockwise from the initial to current state. In Fig. 6F, the initial feature group (image 180) is shown in dashed lines while the current feature group (image 182) is shown in solid lines.

[0058] As shown in Fig. 6G, based on the rotation vector the speaker 192 of the tablet PC 175 increases (or decreases) its output in accordance with the amount of rotation of the fingers 176, i.e., increase the volume by 5% based on rotation of 5 degrees. The display 174 of the tablet PC can also adjust the rotation of the knob 170 in accordance with the amount of rotation of the fingers 176, i.e., the position of the knob 170 rotates five (5) degrees. In most cases, the rotation of the knob occurs simultaneously with the rotation of the fingers, i.e., for every degree of finger rotation the knob rotates a degree. In essence, the virtual control knob follows the gesture occurring on the screen. Still further, an audio unit 194 of the tablet PC may provide a clicking sound for each unit of rotation, e.g., provide five clicks based on rotation of five degrees. Sill yet further, a haptics unit 196 of the tablet PC 175 may provide a certain amount of vibration or other tactile feedback for each click thereby simulating an actual knob.

[0059] It should be noted that additional gestures can be performed simultaneously with the virtual control knob gesture. For example, more than one virtual control knob can be controlled at the same time using both hands, i.e., one hand for each virtual control knob. Alternatively or additionally, one or more slider bars can be controlled at the same time as the virtual control knob, i.e., one hand operates the virtual control knob, while at least one finger and maybe more than one finger of the opposite hand operates at least one slider and maybe more than one slider bar, e.g., slider bar for each finger.

[0060] It should also be noted that although the embodiment is described using a virtual control knob, in another embodiment, the UI element can be a virtual scroll wheel. As an example, the virtual scroll wheel can mimic an actual scroll wheel such as those described in U.S. Patent Publication Nos.: 2003/0076303A1, 2003/0076301A1, 2003/0095096A1, which are all herein incorporated by reference. For example, when the user places their finger on the surface of the virtual scroll wheel and makes a swirling, rotational or tangential gesture motion, a scrolling action can be performed with respect to a list of items displayed in a window.

[0061] Fig. 7 is a diagram of a touch-based method 200 in accordance with one embodiment of the present invention. The method generally begins at block 202 where a user input that occurs over a multipoint sensing device is detected. The user input includes one or more touch inputs, with each touch input having a unique identifier. Following block 202, the touch-based method 200 proceeds to block 204 where the user input is classified as a tracking or selection input when the user input includes a single unique identifier (one touch input), or is classified as a gesture input when the user input includes at least two unique identifiers (more than one touch input). If the user input is classified as a tracking input, the touch-based method 200 proceeds to block 206 where tracking is performed corresponding to the user input. If the user input is classified as a gesture input, the touch-based method 200 proceeds to block 208 where one or more gesture control actions are performed corresponding the user input. The gesture control actions are based at least in part on changes that occur with or between the at least two unique identifiers.

[0062] Fig. 8 is a diagram of a touch-based method 250 in accordance with one embodiment of the present invention. The touch-based method 250 generally begins at block 252 where an initial image is captured during an input stroke on a touch sensitive surface. Following block 252, the touch-based method 250 proceeds to block 254 where the touch mode is determined based on the initial image. For example, if the initial image includes a single unique identifier then the touch mode may correspond to a tracking or selection mode. On the other hand, if the image includes more than one unique identifier, then the touch mode may correspond to a gesture mode. Following block 254, the touch-based method 250 proceeds to block 256 where a next image is captured during the input stroke on the touch sensitive surface. Images are typically captured sequentially during the stroke and thus the there may be a plurality of images associated with the stroke. Following block 256,

touch-based method 250 proceeds to block 258 where a determination is made as to whether the touch mode changed between capture of the initial image and capture of the next image. If the touch mode changed, the touch-based method 250 proceeds to block 260 where the next image is set as the initial image and thereafter the touch mode is again determined at block 254 based on the new initial image. If the touch mode stayed the same, the touch-based method 250 proceeds to block 262 where the initial and next images are compared and one or more control signals are generated based on the comparison.

[0063] Fig. 9 is a diagram of a touch-based method 300 in accordance with one embodiment of the present invention. The touch-based method 300 begins at block 302 where a GUI object is output. For example, a processor may instruct a display to display a particular GUI object. Following block 302, the touch-based method 300 proceeds to block 304 where a gesture input is received over the GUI object. For instance, a user may set or move their fingers in a gestural way on the surface of the touch screen and while over the displayed GUI object. The gestural input may include one or more single gestures that occur consecutively or multiple gestures that occur simultaneously. Each of the gestures generally has a particular sequence, motion, or orientation associated therewith. For example, a gesture may include spreading fingers apart or closing fingers together, rotating the fingers, translating the fingers, and/or the like.

[0064] Following block 304 the touch-based method 300 proceeds to block 306 where the GUI object is modified based on and in unison with the gesture input. By modified, it is meant that the GUI object changes according to the particular gesture or gestures being performed. By in unison, it is meant that the changes occur approximately while the gesture or gestures are being performed. In most cases, there is a one to one relationship between the gesture(s) and the changes occurring at the GUI object and they occur substantially simultaneously. In essence, the GUI object follows the motion of the fingers. For example, spreading of the fingers may simultaneously enlarge the object, closing of the fingers may simultaneously reduce the GUI object, rotating the fingers may simultaneously rotate the object, translating the fingers may allow simultaneous panning or scrolling of the GUI object.

[0065] In one embodiment, block 306 may include determining which GUI object is associated with the gesture being performed, and thereafter locking the displayed object to the fingers disposed over it such that the GUI object changes in accordance

with the gestural input. By locking or associating the fingers to the GUI object, the GUI object can continuously adjust itself in accordance to what the fingers are doing on the touch screen. Often the determination and locking occurs at set down, i.e., when the finger is positioned on the touch screen.

[0066] Fig. 10 is a diagram of a zoom gesture method 350, in accordance with one embodiment of the present invention. The zoom gesture may be performed on a multipoint touch screen. The zoom gesture method 350 generally begins at block 352 where the presence of at least a first finger and a second finger are detected on a touch sensitive surface at the same time. The presence of at least two fingers is configured to indicate that the touch is a gestural touch rather than a tracking touch based on one finger. In some cases, the presence of only two fingers indicates that the touch is a gestural touch. In other cases, any number of more than two fingers indicates that the touch is a gestural touch. In fact, the gestural touch may be configured to operate whether two, three, four or more fingers are touching, and even if the numbers change during the gesture, i.e., only need a minimum of two fingers at any time during the gesture.

[0067] Following block 352, the zoom gesture method 350 proceeds to block 354 where the distance between at least the two fingers is compared. The distance may be from finger to finger or from each finger to some other reference point as for example the centroid. If the distance between the two fingers increases (spread apart), a zoom-in signal is generated as shown in block 356. If the distance between two fingers decreases (close together), a zoom-out signal is generated as shown in block 358. In most cases, the set down of the fingers will associate or lock the fingers to a particular GUI object being displayed. For example, the touch sensitive surface can be a touch screen, and the GUI object can be displayed on the touch screen. This typically occurs when at least one of the fingers is positioned over the GUI object. As a result, when the fingers are moved apart, the zoom-in signal can be used to increase the size of the embedded features in the GUI object and when the fingers are pinched together, the zoom-out signal can be used to decrease the size of embedded features in the object. The zooming typically occurs within a predefined boundary such as the periphery of the display, the periphery of a window, the edge of the GUI object, and/or the like. The embedded features may be formed on a plurality of layers, each of which represents a different level of zoom. In most cases, the amount of zooming varies according to the distance between the two objects. Furthermore, the zooming

typically can occur substantially simultaneously with the motion of the objects. For instance, as the fingers spread apart or closes together, the object zooms in or zooms out at the same time. Although this methodology is directed at zooming, it should be noted that it may also be used for enlarging or reducing. The zoom gesture method 350 may be particularly useful in graphical programs such as publishing, photo, and drawing programs. Moreover, zooming may be used to control a peripheral device such as a camera, i.e., when the finger is spread apart, the camera zooms out and when the fingers are closed the camera zooms in.

[0068] Figs. 11A-11H illustrate a zooming sequence using the method described above. Fig. 11A illustrates a display presenting a GUI object 364 in the form of a map of North America with embedded levels which can be zoomed. In some cases, as shown, the GUI object is positioned inside a window that forms a boundary of the GUI object 364. Fig. 11B illustrates a user positioning their fingers 366 over a region of North America 368, particularly the United States 370 and more particularly California 372. In order to zoom in on California 372, the user starts to spread their fingers 366 apart as shown in Fig. 11C. As the fingers 366 spread apart further (distance increases), the map zooms in further on Northern California 374, then to a particular region of Northern California 374, then to the Bay area 376, then to the peninsula 378 (e.g., the area between San Francisco and San Jose Area), and then to the city of San Carlos 380 located between San Francisco and San Jose as illustrated in Figs. 11D-11H. In order to zoom out of San Carlos 380 and back to North America 368, the fingers 366 are closed back together following the sequence described above, but in reverse.

[0069] Fig. 12 is a diagram of a pan method 400, in accordance with one embodiment of the present invention. The pan gesture may be performed on a multipoint touch screen. The pan method 400 generally begins at block 402 where the presence of at least a first object and a second object are detected on a touch sensitive surface at the same time. The presence of at least two fingers is configured to indicate that the touch is a gestural touch rather than a tracking touch based on one finger. In some cases, the presence of only two fingers indicates that the touch is a gestural touch. In other cases, any number of more than two fingers indicates that the touch is a gestural touch. In fact, the gestural touch may be configured to operate whether two, three, four or more fingers are touching, and even if the numbers change during the gesture, i.e., only need a minimum of two fingers. Following block 402, the pan method 400

proceeds to block 404 where the position of the two objects when the objects are moved together across the touch screen is monitored. Following block 404, the pan method 400 proceeds to block 406 were a pan signal is generated when the position of the two objects changes relative to an initial position. In most cases, the set down of the fingers will associate or lock the fingers to a particular GUI object displayed on the touch screen. Typically, when at least one of the fingers is positioned over the image on the GUI object. As a result, when the fingers are moved together across the touch screen, the pan signal can be used to translate the image in the direction of the fingers. In most cases, the amount of panning varies according to the distance the two objects move. Furthermore, the panning typically can occur substantially simultaneously with the motion of the objects. For instance, as the fingers move, the object moves with the fingers at the same time.

[0070] Figs. 13A-13D illustrate a panning sequence based on the pan method 400 described above. Using the map of Fig. 11, Fig. 13A illustrates a user positioning their fingers 366 over the map. Upon set down, the fingers 366 are locked to the map. As shown in Fig. 13B, when the fingers 366 are moved vertically up, the entire map 364 is moved up thereby causing previously seen portions of map 364 to be placed outside the viewing area and unseen portions of the map 364 to be placed inside the viewing area. As shown in Fig. 13C, when the fingers 366 are moved horizontally sideways, the entire map 364 is moved sideways thereby causing previously seen portions of map 364 to be placed outside the vowing area and unseen portions of the map to be placed inside the viewing area. As shown in Fig. 13D, when the fingers 366 are moved diagonally, the entire map 364 is moved diagonally thereby causing previously seen portions of map 364 to be placed outside the viewing area and unseen portions of the map to be placed inside the viewing area. As should be appreciated, the motion of the map 364 follows the motion of the fingers 366. This process is similar to sliding a piece of paper along a table. The pressure the fingers exert on the paper locks the paper to the fingers and when the fingers are slid across the table, the piece of paper moves with them.

[0071] Fig. 14 is a diagram of a rotate method 450, in accordance with one embodiment of the present invention. The rotate gesture may be performed on a multipoint touch screen. The rotate method 450 generally begins at block 452 where the presence of a first object and a second object are detected at the same time. The presence of at least two fingers is configured to indicate that the touch is a gestural

touch rather than a tracking touch based on one finger. In some cases, the presence of only two fingers indicates that the touch is a gestural touch. In other cases, any number of more than two fingers indicates that the touch is a gestural touch. In fact, the gestural touch may be configured to operate whether two, three, four or more fingers are touching, and even if the numbers change during the gesture, i.e., only need a minimum of two fingers.

[0072] Following block 452, the rotate method 450 proceeds to block 454 where the angle of each of the finger is set. The angles are typically determined relative to a reference point. Following block 454, rotate method 450 proceeds to block 456 where a rotate signal is generated when the angle of at least one of the objects changes relative to the reference point. In most cases, the set down of the fingers will associate or lock the fingers to a particular GUI object displayed on the touch screen. Typically, when at least one of the fingers is positioned over the image on the GUI object, the GUI object will be associated with or locked to the fingers. As a result, when the fingers are rotated, the rotate signal can be used to rotate the object in the direction of finger rotation (e.g., clockwise, counterclockwise). In most cases, the amount of object rotation varies according to the amount of finger rotation, i.e., if the fingers move 5 degrees then so will the object. Furthermore, the rotation typically can occur substantially simultaneously with the motion of the fingers. For instance, as the fingers rotate, the object rotates with the fingers at the same time.

[0073] Figs. 15A-15C illustrate a rotating sequence based on the method described above. Using the map of Fig. 11, Fig. 15A illustrates a user positioning their fingers 366 over the map 364. Upon set down, the fingers 366 are locked to the map 364. As shown in Fig. 15B, when the fingers 366 are rotated in a clockwise direction, the entire map 364 is rotated in the clockwise direction in accordance with the rotating fingers 366. As shown in Fig. 15C, when the fingers 366 are rotated in a counterclockwise direction, the entire map 364 is rotated in the counter clockwise direction in accordance with the rotating fingers 366.

[0074] It should be noted that the methods described in Figs. 10-15 can be implemented during the same gestural stroke. That is, zooming, rotating and panning can all be performed during the gestural stroke, which may include spreading, rotating and sliding fingers. For example, upon set down with at least two fingers, the displayed object (map) is associated or locked to the two fingers. In order to zoom, the user can spread or close their fingers. In order to rotate, the user can rotate their

fingers. In order to pan, the user can slid their fingers. Each of these actions can occur simultaneously in a continuous motion. For example, the user can spread and close their fingers while rotating and sliding them across the touch screen. Alternatively, the user can segment each of these motions without having to reset the gestural stroke. For example, the user can first spread their fingers, then rotate their fingers, then close their fingers, then slide their fingers and so on.

[0075] Fig. 16 is a diagram of a GUI operational method 500, in accordance with one embodiment of the present invention. The GUI operational method 500 is configured for initiating floating controls in a GUI. The GUI operational method 500 generally begins at block 502 where the presence of an object such as a finger or thumb is detected. This may for example be accomplished using a touch screen. Following block 502, the GUI operational method 500 proceeds to block 504 where the object is recognized (the identity of the object is found). The object may be recognized among a plurality of objects. For example, see block 104 of Fig. 2 above.

[0076] Following block 504, the GUI operational method 500 proceeds to block 506 where an image in the vicinity of the object is generated. The image is typically based on the recognized object . The image may include windows, fields, dialog boxes, menus, icons, buttons, cursors, scroll bars, etc. In some cases, the user can select and activate the image (or features embedded therein) in order to initiate functions and tasks. By way of example, the image may be a user interface element or a group of user interface elements (e.g., one or more buttons that open, close, minimize, or maximize a window). The image may also be one or more icons that launch a particular program or files that open when selected. The image may additionally correspond to non interactive text and graphics. In most cases, the image is displayed as long as the object is detected or it may be displayed for some preset amount of time, i.e., after a period of time it times out and is removed.

[0077] In one particular embodiment, the image includes one or more control options that can be selected by the user. The control options may include one or more control buttons for implementing various tasks. For example, the control option box may include music listening control buttons as for example, play, pause, seek and menu.

[0078] Figs. 17A-17E illustrate a floating control sequence using the method described above. As shown in Fig. 17A, a user 510 is using a tablet PC 512 and therefore is holding the tablet PC 512 with one hand 514 while navigating (e.g., tracking, gesturing) with the other hand 516. As shown in Fig. 17B, which is a close

up of the user holding the tablet PC 512, a portion of the thumb of the holding hand 514 is positioned over the touch screen 520. As shown in Fig. 17C, the tablet PC 512 recognizes the thumb and displays a control box 522 adjacent the thumb. The control box 522 includes various buttons 524, which can be selected by the user's thumb to initiate tasks in the tablet PC 512. As shown in Fig. 17D, while holding the tablet PC 512, the thumb is extended over one of the buttons 524 and subsequently tapped thereby selecting the task associated with the button 524. By way of example, the task may be associated with launching a program or gaining access to a network or changing the mode of operation of the device. The control box 522 and buttons 524 may be used to change the input mode of the touch screen 520 so that, for example, the identical gesture made with the fingers of the user's other hand may have multiple meanings depending on which of buttons 524 is selected. As shown in Fig. 17E, when the thumb is moved away from the touch screen 520, the control box 522 may time out and disappear. Alternatively, the control box may be closed using conventional close icons or buttons.

[0079] Fig. 18 is a diagram of a GUI operational method 550, in accordance with one embodiment of the present invention. The GUI operational method 550 is configured for initiating zooming targets. The GUI operational method 550 generally begins at block 552 where a control box GUI element is displayed. The control box contains one or more control buttons, which are somewhat close together, and which can be used to perform actions. The control box may, for example, include control buttons such as maximize, minimize, close, and the like. Following block 552, the GUI operational method 550 proceeds to block 554 where the control box is enlarged, or at least one of the control buttons is enlarged for a period of time when the presence of an object over the control box or one of the control buttons is detected. In the case where the control box is enlarged each of the control buttons is enlarged thereby making selection thereof much easier. In the case where only the control button is enlarged, the user would decide whether this is the correct button and if so select the enlarged control button, or restart the process so that the appropriate control button is presented. In most cases, the size of the control buttons corresponds to the size of the finger so that they may be easily selected by the object. Following block 554, the GUI operational method 550 proceeds to block 556 where a control signal associated with the selected control button is generated when the presence of the object over one of the enlarged control buttons is detected.

[0080] Figs. 19A-19D illustrate a zooming target sequence using the GUI operational method 550 described above. As shown in Fig. 19A, a user 510 places their finger 576 over a control box 578. Because the buttons 580 of the control box 578 included therein are smaller than the finger 576 and located close together, it is difficult for the user 510 to make a selection directly without possibly pressing an undesirable button 580, e.g., a button adjacent the desired button. By way of example, the finger 576 may cover two or more of the buttons 580. As shown in Fig. 19B, at least a portion of the control box 578 is enlarged including the buttons 580 included therein when the user places their thumb over the control box. As shown in Fig. 19C, once the control box has reached its enlarged state, the user can select one of the enlarged buttons, which is now closer to the size of the thumb. By way of example, the user may tap on the desired control button. As shown in Fig. 19D, the control box reduces to its initial size after the button is selected or after a predetermined time period in which no selection was made (e.g., times out) or when the user moves their finger away from the control box.

[0081] Fig. 20 is a diagram of a GUI operational method 600, in accordance with one embodiment of the present invention. The GUI operational method 600 is configured for initiating a page turn. The GUI operational method 600 generally begins at block 602 where a page from a multitude of pages is displayed in a GUI. By way of example, the pages may be associated with an electronic book. Following block 602, the GUI operational method 600 proceeds to block 604 where the presence of an object (or objects) in a predetermined region over the page is detected. The predetermined area may, for example, correspond to the area where the page number is displayed. Following block 604, the GUI operational method 600 proceeds to block 606 where a page turn signal is generated when the object (or objects) is translated in the predetermined region. The translation is configured to simulate a finger turning the page in an actual paper bound book. The direction of the translation indicates whether to go to the next page or previous page in the list of pages. For example, if the finger is swiped right to left, then a page back signal is generated, and if the finger is swiped left to right, then a page up signal is generated. This GUI operational method 600 may be enhanced several ways. For instance, if multiple fingers are swiped, then this may create a paging signal greater than one page. For example, a two finger swipe equals two page turns, three finger swipe

equals three page turns, etc. Or a two finger swipe equals ten page turns, three finger swipe equals 50 page turns, etc.

[0082] Figs. 21A-21D illustrate a page turning sequence using the GUI operational method 600 described above. As shown in Fig. 21A, which is a close up of a user 510 holding the tablet PC 512, the user swipes their finger over the page number in a direction to the left of the page 630. As shown in Fig. 21B, the tablet PC 512 recognizes the swipe and direction of the swipe in the area of the page number and therefore the tablet PC 512 displays the next page in a group of pages. This can be performed repeatedly to whisk through the group of pages. As shown in Fig. 21C, the user swipes their finger 576 over the page number in a direction to the right of the page 630. As shown in Fig. 21D, the tablet PC 512 recognizes the swipe and direction of the swipe in the area of the page number and therefore the tablet PC 512 displays the previous page in a group of pages. This can be performed repeatedly to whisk through the group of pages.

[0083] Fig. 22 is a diagram of a GUI operational method 650, in accordance with one embodiment of the present invention. The GUI operational method 650 is configured for initiating inertia typically during a scrolling or panning operation. Inertia is generally defined as the tendency of a body at rest to remain at rest or of a body in motion to stay in motion in a straight line unless disturbed by an external force. In this particular embodiment, the GUI or some portion thereof is associated with inertial properties, which is its resistance to rate of change in motion. For a GUI with high inertia characteristics, the acceleration of the GUI will be small for a given input. On the other hand, if the GUI has low inertia characteristics, the acceleration will be large for a given input.

[0084] The GUI operational method 650 generally begins at block 652 where a graphical image is displayed on a GUI. Following block 652, the GUI operational method 650 proceeds to block 654 where a scrolling or panning stroke on a touch sensitive surface is detected. By way of example, the stroke may be a linear or rotational stroke. During a linear stroke, the direction of scrolling or panning typically follows the direction of the stroke. During a rotational stroke (see Fig. 6), the rotational stroke is typically converted to a linear input where clockwise motion may correspond to vertical up and counterclockwise motion may correspond to vertical down. Following block 654 the process flow proceeds to block 656 where the speed and direction of the scrolling or panning stroke is determined. Following

block 656, the GUI operational method 650 proceeds to block 658 where the image is moved in accordance with the speed and direction of the scrolling or panning stroke as well as the associated inertial characteristics. Following block 658, the GUI operational method 650 proceeds to block 660 where the motion of the image continues even when the panning or scrolling stroke is no longer detected. For example, when the user picks up their finger from the touch sensitive surface, the scrolling or panning function continues as if the scrolling or panning stroke was still being made. In some cases, the motion of the image continues infinitely until some braking (stopping or slowing) control is performed. This particular methodology simulates zero gravity. In other cases, the motion of the image is slowed in accordance with the associated inertia GUI operational method 650. Metaphorically speaking, the image may correspond to a piece of paper moving over a desktop. In order to move the piece of paper, the user exerts a force on the paper in the desired direction. When the user lifts their finger off the paper, the paper will continue to slid along the desktop in the desired direction for some period of time. The amount it slides after lifting the finger generally depends on, among other things, its mass, the force applied by the finger, the friction force found between the paper and the desktop, etc. As should be appreciated, traditionally when scrolling and panning are implemented, the scrolling or panning stops when the fingers are picked up. In contrast, using the above mentioned methodology, the scrolling or panning continues to move when the fingers are picked up.

[0085] The GUI operational method 650 may additionally include blocks A and B. In block A, an object such as a finger is detected on the touch sensitive surface when the image is moving without the assistance of the object (block 660). In block B, the motion of the image is stopped when the object is detected, i.e., the new touch serves as a braking means. Using the metaphor above, while the piece of paper is sliding across the desktop, the user presses their finger on the paper thereby stopping its motion.

[0086] Figs. 23A-23D illustrate an inertia sequence using the method described above. Fig. 23A illustrates a display presenting a GUI 678 including a window 679 having a list 680 of media items 681. The window 679 and list 680 may for example correspond to a control window and music list found in iTunes® manufactured by Apple Computer, Inc of Cupertino, CA. As shown in Fig. 23B, when the user slides their finger or fingers 576 over the touch screen 520, vertical scrolling, which moves

media items up or down through the window, is implemented. The direction of scrolling may follow the same direction as finger movement (as shown), or it may go in the reverse direction. In one particular embodiment, a single finger is used for selecting the media items from the list, and two fingers are used to scroll through the list.

[0087] Scrolling generally pertains to moving displayed data or images (e.g., media items 681) across a viewing area on a display screen so that a new set of data (e.g., media items 681) is brought into view in the viewing area. In most cases, once the viewing area is full, each new set of data appears at the edge of the viewing area and all other sets of data move over one position. That is, the new set of data appears for each set of data that moves out of the viewing area. In essence, these functions allow a user to view consecutive sets of data currently outside of the viewing area. In most cases, the user is able to accelerate their traversal through the data sets by moving his or her finger at greater speeds. Examples of scrolling through lists can be found in U.S. Patent Publication Nos.: 2003/0076303A1, 2003/0076301A1, 2003/0095096A1, which are herein incorporated by reference.

[0088] As shown in Fig. 23C, the displayed data continues to move even when the finger is removed from the touch screen. The continuous motion is based at least in part on the previous motion. For example the scrolling may be continued in the same direction and speed. In some cases, the scrolling slow down over time, i.e., the speed of the traversal through the media items gets slower and slower until the scrolling eventually stops thereby leaving a static list. By way of example, each new media item brought into the viewing area may incrementally decrease the speed. Alternatively or additionally, as shown in Fig. 23D, the displayed data stops moving when the finger 576 is placed back on the touch screen 520. That is, the placement of the finger back on the touch screen can implement braking, which stops or slows down the continuous acting motion. Although this sequence is directed at vertical scrolling it should be noted that this is not a limitation and that horizontal scrolling as well as panning may be performed using the methods described above.

[0089] Fig. 24 is a diagram of a GUI operational method 700, in accordance with one embodiment of the present invention. The method 700 is configured for simulating a keyboard. The method generally begins at block 702 where a keyboard is presented on the display. Following block 702, the process flow proceeds to block 704 where the presence of a first object over a first key and a second object over a second key at

the same time is detected on a touch screen. The touch screen is positioned over or in front of the display. By way of example, the display may be an LCD and the touch screen may be a multipoint touch screen. Following block 704, the process flow proceeds to block 706 where one or more simultaneous control signals are generated when the first object is detected over the first key and when the second object is detected over the second key at the same time.

[0090] In one embodiment, only a single control signal is generated when the first object is detected over the first key and when the second object is detected over the second key at the same time. By way of example, the first key may be a shift key and the second key may be a symbol key (e.g., letters, numbers). In this manner, the keyboard acts like a traditional keyboard, i.e., the user is allowed to select multiple keys at the same time in order to change the symbol, i.e., lower/upper case. The keys may also correspond to the control key, alt key, escape key, function key, and the like.

[0091] In another embodiment, a control signal is generated for each actuated key (key touch) that occurs at the same time. For example, groups of characters can be typed at the same time. In some cases, the application running behind the keyboard may be configured to determine the order of the characters based on some predetermined criteria. For example, although the characters may be jumbled, the application can determine that the correct order of characters based on spelling, usage, context, and the like.

[0092] Although only two keys are described, it should be noted that two keys is not a limitation and that more than two keys may be actuated simultaneously to produce one or more control signals. For example, control-alt-delete functionality may be implemented or larger groups of characters can be typed at the same time.

[0093] Figs. 25A-25D illustrates a keyboard sequence using the method described above. Fig. 25A illustrates a display presenting a GUI object 730 in the form of a keyboard. As shown in Fig. 25B, a user positions their fingers 576 over the multipoint touch screen 520 over the keyboard 730 to enter data into a word processing program. By way of example, the user may place one of their fingers 576A on the Q key in order to produce a lower case "q" in the word processing

program. As shown in Fig. 25C, when the user decides that a letter should be in upper case, the user places one finger 576B on the shift key and another finger 576A on the desired letter (as indicated by the arrows). As shown in Fig. 25D, in order to continue typing in lower case, the user simply removes their finger 576B from the shift key and places their finger 576A over a desired letter (as indicated by the arrow).

[0094] Fig. 26 is a diagram of a GUI operational method 750, in accordance with one embodiment of the present invention. The method 750 is configured for simulating a scroll wheel such as those described in U.S. Patent Publication Nos.: 2003/0076303A1, 2003/0076301A1, 2003/0095096A1, all of which are herein incorporated by reference. The method generally begins at block 752 where a virtual scroll wheel is presented on the display. In some cases, the virtual scroll wheel may include a virtual button at its center. The virtual scroll wheel is configured to implement scrolling as for example through a list and the button is configured to implement selections as for example items stored in the list. Following block 752, the method proceeds to block 754 where the presence of at least one finger and in some cases more than one finger, such as first and second fingers, over the virtual scroll wheel is detected on a touch screen. The touch screen is positioned over or in front of the display. By way of example, the display may be an LCD and the touch screen may be a multipoint touch screen. Following block 754, the method proceeds to block 756 where the initial position of the fingers on the virtual scroll wheel is set. By way of example, the angle of the fingers relative to a reference point may be determined (e.g., 12 o clock, 6 o clock, etc.). In most cases, the set down of the finger(s) associate, link or lock the fingers (or finger) to the virtual scroll wheel when the fingers are positioned over the virtual scroll wheel.

[0095] Following block 756, the method 750 proceeds to block 758 where a rotate signal is generated when the angle of the fingers change relative to the reference point. The rotate signal can be used to perform several actions including for example scrolling through a plurality of media items, and possibly moving the virtual scroll wheel with the finger(s). By way of example, the combination and frequency of the signals may be converted into distance, direction and speed necessary for moving a selector through the media items as well for moving the virtual scroll wheel around its axis. In most cases, the amount of scrolling and wheel rotation varies according to

the amount of finger rotation. By way of example, if the fingers move 5 degrees then so will the wheel. Furthermore, the scrolling and rotation of the wheel typically occurs substantially simultaneously with the motion of the fingers. For instance, as the fingers rotate, both scrolling and rotation of the wheel are performed at the same time. Moreover, although not a requirement, the direction of scrolling and rotation of the wheel is generally the same as the direction of the finger motion. For example, the virtual scroll wheel rotates in the direction of finger rotation (e.g., clockwise, counterclockwise, etc.)

[0096] In some cases, the principals of inertia as described above can be applied to the virtual scroll wheel. In cases such as these, the virtual scroll wheel continues to rotate when the fingers (or one of the fingers) are lifted off of the virtual scroll wheel and slowly comes to a stop via virtual friction. Alternatively or additionally, the continuous rotation can be stopped by placing the fingers (or the removed finger) back on the scroll wheel thereby braking the rotation of the virtual scroll wheel.

[0097] It should be pointed out that a rotating virtual scroll wheel is not a limitation, and in some cases, the virtual scroll wheel may remain stationary (e.g., does not rotate with the fingers) so as to simulate a touch surface rather than a mechanical rotating wheel.

[0098] Figs. 27A-27D illustrates a scroll wheel sequence using the method described above. Fig. 27A illustrates a display presenting a scroll wheel. The scroll wheel may be displayed automatically as part of a program or it may be displayed when a particular gesture is performed. By way of example, during the operation of a music program (such as iTunes® manufactured by Apple Computer Inc., of Cupertino, CA), the virtual scroll wheel may appear on the GUI of the music program when two fingers are placed on the touch screen rather than one finger which is typically used for tracking in the music program. In some cases, the virtual scroll wheel only appears when two fingers are placed on a predetermined area of the GUI. Alternatively, the appearance of the virtual scroll wheel may be based on something other than or in addition to the number of fingers. For example, the virtual scroll wheel may appear in response to any touch that occurs when the music program is running.

[0099] As shown in Fig. 27B, a user positions their fingers over the multipoint touch screen 520 over the scroll wheel. At some point, the fingers are locked to the scroll wheel. This can occur at set down for example. As shown in Fig. 27C, when the fingers are rotated in a clockwise direction, the scroll wheel is rotated in the clockwise direction in accordance with the rotating fingers. As shown in Fig. 27D, when the fingers are rotated in a counterclockwise direction, the virtual scroll wheel is rotated in the counter clockwise direction in accordance with the rotating fingers. Alternatively, rotation of the virtual scroll wheel may also be rotated with linear motion of the fingers in a tangential manner.

[00100] Fig. 28 is user interface method 800, in accordance with one embodiment of the present invention. The user interface method 800 may for example be performed on a computing device having a display and a touch sensitive input device such as a touch screen. The user interface method 800 begins at block 802 where a touch is detected. This may be accomplished with the touch sensitive input device when an object such as a stylus or one or more fingers, is placed on the touch sensitive surface of the touch sensitive input device.

[00101] Once a touch is detected, the user interface method 800 proceeds to block 804 where a user interface (UI) mode is determined in response to the touch. The user interface mode may be widely varied. The user interface mode may include navigation modes, scroll modes, data entry modes, edit modes, control modes, information modes, display modes, etc. Each mode typically has one or more GUI interface elements associated therewith. By way of example, a virtual scroll wheel (e.g., Fig. 27) or slider bar may be associated with a scroll mode, a keyboard (e.g., Fig. 25) or keypad may be associated with data entry mode, a tool bar such as a formatting tool bar or drawing tool bar may be associated with an edit mode, a control panel including buttons may be associated with a control mode, a window may be associated with an information mode, etc.

[00102] The user interface mode may be determined at block 804 based on one or more conditions including for example, one or more applications currently running on the computing device, the current state or mode of the one or more applications and/or the touch characteristics associated with the touch. In fact, determining the

user interface mode at block 804 may involve monitoring and analyzing one or more conditions.

[00103] The current applications may for example include operating systems (e.g., Mac OS), word processing programs, spreadsheet programs, draw editing programs, image editing programs, gaming programs, photo management programs (e.g., iPhoto), music management programs (e.g., iTunes), video editing programs (e.g., iMovie), movie management programs (e.g., QuickTime), music editing programs (e.g., GarageBand), Internet interface programs and/or the like.

[00104] The current state or mode of the applications may correspond to an active portion of the application (e.g., current window or windows within windows). For example, the active portion of a music management program may correspond to a music control mode, a playlist select mode, a menu mode, and/or the like. Further, the active portion of a photo management program may correspond to photo browsing mode or photo editing mode. Further still, the active portion of an internet interface program may correspond to a web mode or an email mode.

[00105] The touch characteristics on the other hand may, for example, correspond to touch location, touch ID, number of touches, etc, as described in many of the embodiments mentioned above.

[00106] With regards to applications, different applications may indicate different UI modes. For example, a word processing or spreadsheet application may indicate a data entry mode, while a music management program may indicate a control or scrolling mode. With regards to the current state of an application, different modes of the application may indicate different UI modes. For example, in a music management program, a menu window may indicate one UI mode, while a playlist window may indicate another UI mode.

[00107] With regards to the touch, the number of fingers may indicate different UI modes. For example, one finger may indicate a first mode while two fingers may indicate a second mode. In addition, the identity of the touch may indicate different UI modes. For example, a thumb may indicate a first UI mode and an index finger may indicate a second UI mode. Moreover, the location of the touch may indicate

different UI modes. For example, a first touch location may indicate a first UI mode, while a second touch location may indicate a second UI mode (if the touch is located over a border of a music program a first UI mode may be implemented, and if the touch is located over a playlist or list of songs in the music program a second UI mode may be implemented.

[00108] In one embodiment, the user interface mode is based on only one of the conditions. For example, the user interface mode is only based on the application, the current state of the application or one of the various touch characteristics as described above. In another embodiment, the user interface mode is based on multiple conditions. For example, the user interface mode may be based on a combination of at least two selected from the application, the current state of the application and the various touch characteristics. By way of example, the application combined with a first touch characteristic may indicate a first UI mode and the same application combined with a second touch characteristic may indicate a second UI mode.

[00109] To cite a few examples, if the application is a word processing or spreadsheet program then the mode may be determined to be a data entry mode so that data can be entered into the spreadsheet (e.g., keyboard). If the application is a music management program and a playlist is currently showing (active portion), the mode may be determined to be a scroll mode so that the items in the list may be scrolled through in order to find a desired item (e.g., scroll wheel). Alternatively, if a song is playing (active portion), the mode may be determined to be a control mode so that the manner in which songs are played can be controlled (e.g., play, stop, seek and volume control options). Further, if the application is a photo management program and a particular photo is displayed (active portion), the mode may be determined to be a control mode so that the photo can be modified (e.g., converting to black and white, removing red eye, and rotate options).

[00110] After determining the user interface mode 804, the user interface method 800 proceeds to block 806 where one or more GUI elements are displayed based on the user interface mode and in response to the touch(s). In some cases, only one GUI element is displayed and in other cases multiple GUI elements are displayed.

The GUI element is typically associated with a particular mode. For example, a slider bar or scroll wheel may be displayed in a scroll mode, a keyboard or keypad may be displayed in a data entry mode, a tool bar may be displayed in an edit mode, various buttons or a control panel may be displayed in a control mode, and information windows may be displayed in an information mode.

[00111] The GUI element may be displayed in a variety of ways. For example, it can be positioned over the currently displayed graphical images, or it can displace the currently displayed graphical images (e.g., minimize, shift, etc.). In some cases, the GUI element is made semi transparent so that the current graphical image disposed below the GUI element can be seen (thereby eliminating minimizing and shifting). This may be helpful when using a scroll wheel to traverse through a list disposed below the scroll wheel. Furthermore, the GUI element can be placed in the vicinity of the touch or it can be placed in some predetermined location. The predetermined location may be based on ergonomics, i.e., what is the best location for the user.

[00112] In addition to the above, the GUI element may be displayed using a transition effect such as growing, fading in, popping up, and in some cases may even pulsate, throb, etc. If the effect is popping up, the GUI element is immediately brought into view. If the effect is growing, as shown in Figs. 29A-29D, a small GUI element 820A (scroll wheel) is initially displayed, and thereafter the GUI element 820A continuously enlarges through various sizes 820B and 820 C until it reaches its desired size 820D. The speed of growth may be based on the pressure of the touch. For example, if the touch pressure is low, the GUI element may grow slowly and if the touch pressure is high, the GUI element may grow more rapidly. In addition, the final size of the GUI element may be based on the length of the touch. For example, the GUI element stops growing when the touch is no longer detected. Alternatively, the speed and size may be user adjustable as for example through a control panel. If the effect is fading, as shown in Figs. 30A-30D, the GUI element 822 is slowly brought into view from nothing, through various levels of distortion or transparency 822A-822C, to a final complete image 822D. The fading can be controlled similarly to growth. For example, the speed and level of fade may be controlled by the pressure and length of touch.

[00113] The transition effect may even carry over to the currently displayed images, i.e., the images currently displayed before the touch was detected. In one embodiment, the opposite effect happens to the currently displayed images. For example, as shown in Figs. 31A-31D, the currently displayed graphical images 826 are minimized smaller and smaller as the GUI element 820 grows larger and larger. Alternatively, if the GUI element immediately pops in, the currently displayed graphical images can immediately pop out or be immediately minimized.

[00114] Once the GUI element is displayed (806), the user interface method 800 proceeds to block 808 where the functionality of the GUI element is enabled. For example, touch event is monitored relative to the GUI element and actions associated with the touch event are performed. The enablement of the GUI element may occur simultaneously with the display of the GUI element so that a user can immediately start using the GUI element once displayed. By way of example, in a scroll mode, a virtual scroll wheel may be displayed and when enabled, the touch events are monitored relative to the scroll wheel. During monitoring, control signals associated with the position of the finger on the scroll wheel are generated as the finger swirls around the virtual scroll wheel. These signals can be used to perform scrolling. For example, the number, combination and frequency of the signals may be converted into distance, direction and speed necessary for moving a selection bar through a list. By way of example, see Figs. 6, 26 and 27 for more detailed descriptions of virtual scroll wheels and how they function.

[00115] At some point after enabling and displaying the GUI element, a determination 812 is made as to whether or not to deactivate the GUI element. The determination 812 can be made in a variety of ways including, for example: 1) the touch is no longer detected, 2) a touch has not been detected for a preset amount of time, 3) a time out occurs (a preset amount of time has gone by since the GUI element was first displayed/enabled), or 4) a user selection (e.g., a user selects a button that closes the GUI element).

[00116] If the determination indicates deactivation, then the method proceeds to block 814 where the GUI element is disabled and removed from display. Once disabled, actions will no longer be performed when a touch event occurs. The

removal of the GUI element from display may function similar to displaying the GUI element in that it can be removed using a transition effect such as slowly fading out, shrinking or immediately disappearing (popping out). The removal transition effect may work opposite the displaying transitioning effect. For example, the GUI element fades out similarly to fading in, shrinks similarly to growth or pops out similarly to popping in. Further, the GUI element can slowly recess and disappear from view while the displaced or shrunken current graphical images can slowly grow back to their original size and shape. If the determination does not indicate deactivation, then the method maintains the display of the GUI element as well as the enablement thereof.

[00117] Fig. 32 is a determination method 850 in accordance with one embodiment of the present invention. The determination method may, for example, correspond to the block 804 in Fig. 28. The determination method begins at block 852 where the current application is determined. The determination method proceeds to block 854 where the current state of the application is determined. Following block 854, the determination method proceeds to block 856 where the touch characteristics associated with the touch are determined. The determination method proceeds to block 860 where a UI mode is selected based on the results from blocks 852-858. By way of example, a set of rules may indicate appropriate UI modes for a particular set of conditions.

[00118] Fig. 33 is a user interface method 900 in accordance with one embodiment of the present invention. The method may, for example, be performed on a computing device having a display and a touch sensitive input device such as a touch screen. The interface method 900 begins at block 902 where a list of songs are displayed. Fig. 34A shows one example of a window 930A including a list of songs 932A, and Fig. 35A shows another example of a window 930B including a list of songs 932B. Fig. 34A may, for example, be a graphical user interface displayed on an iPod® manufactured by Apple Computer of Cupertino, CA, and Fig. 35A may for example be a graphical user interface associated with a music management program, such as iTunes® manufactured by Apple Computer of Cupertino, CA.

[00119] Following block 902, the user interface method 900 proceeds to block 904 where a touch is detected over the displayed list of songs (or window or entire GUI). This may be accomplished with the touch sensitive input device when an object such as a stylus or one or more fingers is placed on the touch sensitive surface of the touch sensitive input device such as a touch screen. Figs. 34B and 35B show a finger 925 placed over the window 930 including the list of songs 932.

[00120] Once a touch is detected, the user interface method 900 proceeds to block 906 where a virtual scroll wheel is activated. That is, a virtual scroll wheel is displayed in addition to the list of songs and its functionality is enabled. In essence, because the song list was touched, a scroll wheel that allows a user to traverse through the songs in the list of songs is provided. In some cases, the virtual scroll wheel displaces the media items, i.e., the media items are minimized or shifted to make room for the virtual scroll wheel. In other cases, the virtual scroll wheel is positioned or laid over the media items (the media items keep their current size, shape and position). The virtual scroll wheel can be made semi-transparent so that the media items can be viewed through the virtual scroll wheel. Figs. 34C and 35C show a transparent virtual scroll 936 wheel laid over the window 930 including the list of songs 932. Alternatively, a virtual slider bar may be displayed.

[00121] Once displayed, a determination 908 is made as to whether or not a scrolling touch event (or gesture) is performed relative to the virtual scroll wheel. For example, whether or not a finger is positioned over the scroll wheel and whether or not the finger is moved around the scroll wheel in a swirling fashion.

[00122] If a scrolling touch event is performed by the user, the user interface method 900 proceeds to block 910 where scrolling is implemented through the list of songs in accordance with the scrolling touch event. By way of example, a selector bar may be moved from one song to another as the finger is swirled around the virtual scroll wheel. Figs. 34D and 35D show the finger 925 swirling around the virtual scroll wheel 936, and a selector bar 938 moving linearly through the list of songs 932 in accordance with the swirling finger 925. In the illustrated embodiments, the selector bar is moved linearly up when the finger is swirled in a clockwise fashion and linearly down when the finger is swirled in a counterclockwise fashion. It should

be noted, however, that this is not a limitation. For example, the selector bar may moved linearly down when the finger is swirled in a clockwise fashion and linearly up when the finger is swirled in a counterclockwise fashion.

[00123] If a scrolling or select touch event is not performed, the user interface method 900 proceeds to block 916 where the virtual scroll wheel is deactivated. That is, the virtual scroll wheel is disabled and removed from the display. Figs. 34E and 35E show the display 928 without the virtual scroll wheel 936. Although the virtual scroll wheel 936 is removed, changes made to the list of songs, i.e., the position of the selector bar 938, typically remain.

[00124] In some cases, the virtual scroll wheel may include button zones across its surface or a virtual button at its center or around its sides. The buttons and button zones may for example correspond to menu, play, seek, pause, and/or the like. In this particular embodiment, the method described above may include additional steps that occur before block 416. For example, if a scrolling touch event is not performed, the user interface method 900 may include an additional block where a determination is made as to whether or not a selection touch event (or gesture) is performed relative to the virtual scroll wheel. The selection touch event may be implemented by tapping the button or by exerting increased or decreased pressure on the button rather than swirling around the surface of the virtual scroll wheel (see Figs. 34F and 35F). If the button is a song select or enter button, the method include another block where the song with the selector bar disposed thereover is selected. That is, when the virtual button is tapped, or otherwise selected, the song currently covered by the selector bar is played and outputted for the user's enjoyment.

[00125] It should be noted that the methods described above are not limited to scrolling through a list of songs. Any media item as well as any group of elements can be scrolled through using the aforementioned technique. For example, in photo layout 942 as shown in Figs. 36A-36C, the virtual scroll wheel 936 may appear when the user places their finger 925 over the photo layout 942 (or grouping), and thereafter it can be used to move a highlighter 944 through the various photos 943 in the layout 942. By way of example, the photos may be thumbnails images that make traversing through a large number of images easier.

[00126] Fig. 37 is a method 950, in accordance with one embodiment of the present invention. The method begins at block 952 where it is determined if a touch is detected. If a touch is detected, the method proceeds to block 954 where the current operating conditions are monitored and analyzed. The conditions may for example correspond to the current application, the state of the application and/or the touch characteristics associated with the touch.

[00127] If a first set of conditions are implemented, the method proceeds to block 956 where a first GUI element is activated. For example, as shown in Figs. 38A-B, in an active window 960 of a music management program, a scroll wheel 962 may be activated when a user touches a playlist portion 964 of the active window 960.

[00128] If a second set of conditions are implemented, the method proceeds to block 958 where a second GUI element is activated. For example, as shown in Figs. 38B-C, in the active window 960 of a music management program, a music control panel 966 may be activated when a user also touches a border 968 of the active window 960. Although they work independent of one another, the first and second GUI elements may be activated at the same time if the first and second conditions occur simultaneously (Fig. 34C).

[00129] Following block 956, the method proceeds to block 960 where it is determined if the first GUI element should be deactivated. If so, the method proceeds to block 962 where the GUI element is deactivated. For example, as shown in Fig. 38D, the first GUI element (scroll wheel 962) is disabled and removed from display when the finger 925 is no longer detected over the playlist 962. If not, the method maintains block 956.

[00130] Similarly but independently, following block 958, the method proceeds to block 964 where it is determined if the second GUI element should be deactivated. If so, the method proceeds to block 966 where the GUI element is deactivated. For example, as shown in Fig. 38E, the second GUI element (control

panel 966) is disabled and removed from display when the finger 925 is no longer detected over the border 968. If not, the method maintains block 958.

[00131] It should be noted that the method is not limited to only two GUI elements and that other GUI elements may be activated if other conditions are implemented. For example, a third GUI element may be activated when a third set of condition occurs and so on. By way of example, as shown in Fig. 38F, the user may slide their finger 925 from the border 968 to a menu portion 970 of the active window 960 thereby initiating a change from the control panel 966 to a scroll wheel 972 (e.g., while the second GUI element is being deactivated, the third GUI element is being activated).

[00132] Further, as shown in Fig. 38G, the user may add another finger 925 to the current touch thereby initiating a change from the first control panel 966 to a second control panel 982. The first control panel 966 may include a first set of control options such as play, stop, seek and volume options and the second control panel 982 may include a second set of control options such as song playing order, song information, light effect options.

[00133] Moreover, as shown in Fig. 38H, the user may place one finger 925A over the border 968, another finger 925B over a menu portion 970, and yet another finger 925C over the playlist portion 964 thereby initiating three different GUI elements, particularly, a control panel 966, a first scroll wheel 972 for scrolling through the menu 970, and a second scroll wheel 962 for scrolling through the playlist 964.

[00134] In addition, multiple GUI elements can be activated in the same portion. For example, as shown in Figs. 38I and 38J, if the user selects a particular box 990 in the playlist 964, a keyboard 992 may be activated so that the user can enter data associated with the song (e.g., title, artist, genre, etc.). If the scroll wheel 962 is active at the same time as the keyboard 992, the scroll wheel 962 may be minimized to accommodate the keyboard 992 as shown. Once the keyboard 992 is deactivated, the scroll wheel 962 reverts back to its original size.

[00135] The various aspects, embodiments, implementations or features of the invention can be used separately or in any combination.

[00136] The invention is preferably implemented by hardware, software or a combination of hardware and software. The software can also be embodied as computer readable code on a computer readable medium. The computer readable medium is any data storage device that can store data which can thereafter be read by a computer system. Examples of the computer readable medium include read-only memory, random-access memory, CD-ROMs, DVDs, magnetic tape, optical data storage devices, and carrier waves. The computer readable medium can also be distributed over network-coupled computer systems so that the computer readable code is stored and executed in a distributed fashion.

[00137] While this invention has been described in terms of several preferred embodiments, there are alterations, permutations, and equivalents, which fall within the scope of this invention. For example, although the invention has been primarily directed at touchscreens, it should be noted that in some cases touch pads may also be used in place of touchscreens. Other types of touch sensing devices may also be utilized. It should also be noted that there are many alternative ways of implementing the methods and apparatuses of the present invention. It is therefore intended that the following appended claims be interpreted as including all such alterations, permutations, and equivalents as fall within the true spirit and scope of the present invention.

What is claimed is:

1. A user interface method, comprising:

detecting a touch;

determining a user interface mode when a touch is detected;

displaying one or more GUI elements based on the user interface mode; and

enabling the functionality of the GUI element.

2. The user interface method as recited in claim 1 wherein the user interface mode is based on one or more applications.

3. The user interface method as recited in claim 2 wherein different applications indicate different user interface modes.

4. The user interface method as recited in claim 1 wherein the user interface mode is based on a current state of an application.

5. The user interface method as recited in claim 5 wherein different states of the application indicate different user interface modes.

6. The user interface method as recited in claim 1 wherein the user interface mode is based on one or more touch characteristics of the detected touch.

7. The user interface method as recited in claim 6 wherein different characteristics of the touch indicate different modes.

8. The user interface method as recited in claim 1 wherein the user interface mode is based on only one condition, the condition being selected from application, a state of an application, a touch characteristic of the detected touch.

9. The user interface method as recited in claim 1 wherein the user interface mode is based on multiple conditions, the conditions being selected from one or more applications, one or more states of an application, one or more touch characteristics of the detected touch.

10. The user interface method as recited in claim 1-9 wherein only one GUI element is displayed.

11. The user interface method as recited in claim 1-9 wherein multiple GUI elements are displayed.

12. The user interface method as recited in claim 19 wherein the user interface mode is a scroll mode, and wherein the GUI element is a virtual scroll wheel.

13. The user interface method as recited in claim 1-9 wherein the user interface mode is a data entry mode, and wherein the GUI element is a virtual keyboard.

14. The user interface method as recited in claim 1-9 wherein the user interface mode is an edit mode, and wherein the GUI element is a tool bar or virtual keyboard.

15. The user interface method as recited in claim 1-9 wherein the user interface mode is a control mode, and wherein the GUI element is a control panel.

16. The user interface method as recited in claim 1-9 wherein the user interface mode is an information mode, and wherein the GUI element is a window.

17. The user interface method as recited in claim 1-9 wherein the GUI element is displayed over a previously existing graphical image.

18. The user interface method as recited in claim 17 wherein the GUI element is semitransparent so that the previously existing graphical image disposed underneath the GUI element can be seen through the GUI element.

19. The user interface method as recited in claim 1-9 wherein the GUI element is configured to displace a previously existing graphical image.

20. The user interface method as recited in claim 1-9 wherein the GUI element is presented in the vicinity of the detected touch.

21. The user interface method as recited in claim 1-9 wherein the GUI element is presented at a predetermined location.

22. The user interface method as recited in claim 1-9 wherein the displaying the GUI element includes implementing a transition effect that transitions the GUI element from a first state to a second state.

23. The user interface method as recited in claim 22 wherein the transitioning effect is selected from popping, growing, or fading in and out.

24. The user interface method as recited in claim 22 wherein the speed of the transition effect is based on the pressure of the touch.

25. The user interface method as recited in claim 1-9 wherein enabling the GUI element includes monitoring a touch event relative to the GUI element, and performing actions associated with the touch event.

26. The user interface method as recited in claim 1-9 further comprising:

determining whether or not to deactivate the GUI element, deactivation including disabling the functionality of the GUI element and removing the GUI element from display.

27. The user interface method as recited in claim 26 wherein the GUI element is deactivated when a touch is no longer detected.

28. The user interface method as recited in claim 26 wherein the GUI element is deactivated when a touch has not been detected for a preset amount of time.

29. The user interface method as recited in claim 26 wherein the GUI element is deactivated after being activated for a preset amount of time.

30. The user interface method as recited in claim 26 wherein the GUI element is deactivated via a user selection.

31. The user interface method as recited in claim 1-9 wherein displaying the GUI element includes implementing a transition effect that transitions the GUI element from a first state to a second state, and wherein the step of removing the displayed GUI element includes implementing a reverse transition effect that transitions the GUI element from the second state to the first state.

32. The user interface method as recited in claim 1-9 wherein determining the user interface mode comprises:

determining a current application;

determining a current state of the current application; and

determining touch characteristics associated with the detected touch.

33. A method for scrolling through media items, the method comprising:

displaying a plurality of media items;

detecting a touch over at least one of the media items that are displayed;

activating a virtual scroll wheel when a touch is detected over the displayed media items,;

determining if a touch event is performed relative to the touch region of the virtual scroll wheel; and

scrolling through the group of media items when a scrolling touch event is performed.

34. The method as recited in claim 33 wherein activating the virtual scroll wheel includes displaying and enabling the functionality of the virtual scroll wheel, the virtual scroll wheel providing a touch region where a user swirls their finger in order to traverse through the group of media items

35. The method as recited in claim 34 further comprising:

deactivating the virtual scroll wheel when a touch event is not performed, the deactivation of the virtual scroll wheel including disabling the functionality of the virtual scroll wheel and removing the virtual scroll wheel from display.

36. The method as recited in claim 35 wherein the display and the removal of the virtual scroll wheel from display are performed with a transition effect that transitions the virtual scroll wheel from a first state to a second state when displayed, and that transitions the virtual scroll wheel from the second state to the first state when removed.

37. The method as recited in claim 34 wherein the virtual scroll wheel is displayed with a transition effect that transitions the virtual scroll wheel from a first state to a second state.

38. The method as recited in claim 34 wherein the transition effect causes the virtual scroll wheel to grow, a small virtual scroll wheel being initially displayed, and thereafter the virtual scroll wheel continuously enlarging until the virtual scroll wheel reaches a final size.

39. The method as recited in claim 34, 37 and 38 wherein the virtual scroll wheel is displayed over the plurality of media items, and wherein the virtual scroll wheel is semitransparent so that the plurality of media items disposed underneath the virtual scroll wheel can be seen through the virtual scroll wheel.

40. The method as recited in claim 33-39 wherein scrolling includes moving a selector bar linearly through the group of media items in accordance with the touch event occurring on the virtual scroll wheel.

41. The method as recited in claim 33-40 wherein the virtual scroll wheel provides one or more virtual buttons, and wherein the method further comprises:

determining if a selection touch event is performed relative to the one or more virtual buttons of the virtual scroll wheel; and

implementing an action associated with a particular button when the selection touch event is performed on the particular button.

42. The method as recited in claim 41 wherein the one or more virtual buttons include at least a center button that is surrounded by the touch region.

43. The method as recited in claim 42 wherein the virtual scroll wheel is circular.

44. The method as recited in claim 33-40 wherein the step of determining if a touch event is performed relative to the touch region of the virtual scroll wheel comprises:

detecting the presence of at least one finger over the touch region;

setting an initial position of the finger; and

monitoring finger movement relative to the initial position.

45. The method as recited in claim 33-40 wherein the media items are a list of songs.

46. A method performed on a user operated electronic device having a display and a touch screen, the method comprising:

determining if a touch is detected;

monitoring and analyzing the current operating conditions when a touch is detected;

activating a first GUI element for a first set of operating conditions; and

activating a second GUI element for a second set of operating conditions.

47. A method performed on a computing device having a display and a touch sensing input device, the method comprising:

sensing touches;

displaying and enabling a GUI element when a touch is detected, the GUI element being based on at least one of the following:

(a) the application currently running on the computing device;

(b) the current state of the application;

(c) one or more characteristics of the touch, the characteristics including,

(i) touch location,

(ii) touch ID

(iii) number of touches,

(iv) touch motion

disabling and removing the GUI element from display when one of the following events occurs,

(a) the touch is no longer detected,

(b) a touch has not been detected for a preset amount of time,

(c) a certain amount of time has gone by since the step of displaying and enabling,

(d) a user selection.

48. A computing system, comprising:

a display device configured to display a graphical user interface;

a touch screen positioned over the display device, the touch screen being configured to detect touches that occur over the display device; and

a processor operatively coupled to the display device and the touch screen, the processor instructing the display device to display one or more GUI elements in response to a touch, and performing actions associated with the GUI element when touch events are detected relative to the displayed GUI elements.

49. The system as recited in claim 48 wherein the processor is configured to determine a user interface mode in response to the touch, the user interface mode having one or more GUI elements associated therewith that are capable of being displayed, the user interface modes being based on at least one of a current application, a state of the application and a touch characteristics associated with the touches.

50. A computing device, comprising:

a processor;

a touch screen capable of sensing touch events; and

a display configured to simultaneously display a plurality of media items and a virtual scroll wheel, the virtual scroll wheel providing a region where touch events are performed in order to implement a scrolling action, the scrolling action allowing a user to traverse through the plurality of media items.

51. A computer implemented method for initiating floating controls via a touch sensitive device, the method comprising:

detecting the presence of an object on the touch sensitive device;

recognizing the object; and

generating a user interface element on the touch screen in the vicinity of the object based on the recognized object.

52. The method as recited in claim 51, wherein the user interface element includes one or more control options that can be selected by a user of the touch sensitive device.

53. The method as recited in claim 52 further comprising generating a control signal when one of the control options is selected by the object.

54. The method as recited in claim 53 wherein the control signal modifies the functionality of the computer.

55. The method as recited in claim 53 wherein the control signal modifies a user interface element.

56. The method as recited in claim 51-55 wherein the object is a finger or a stylus.

57. A computer implemented method comprising:

presenting a virtual wheel;

detecting at least a first finger over the virtual wheel;

associating the finger to the virtual wheel; and

generating control signals when the finger is moved about the virtual wheel.

58. The method as recited in claim 57 further comprising:

rotating the presented virtual wheel when the finger is moved about the virtual wheel.

59. The method as recited in claim 57 wherein the control signals implement scrolling on a display.

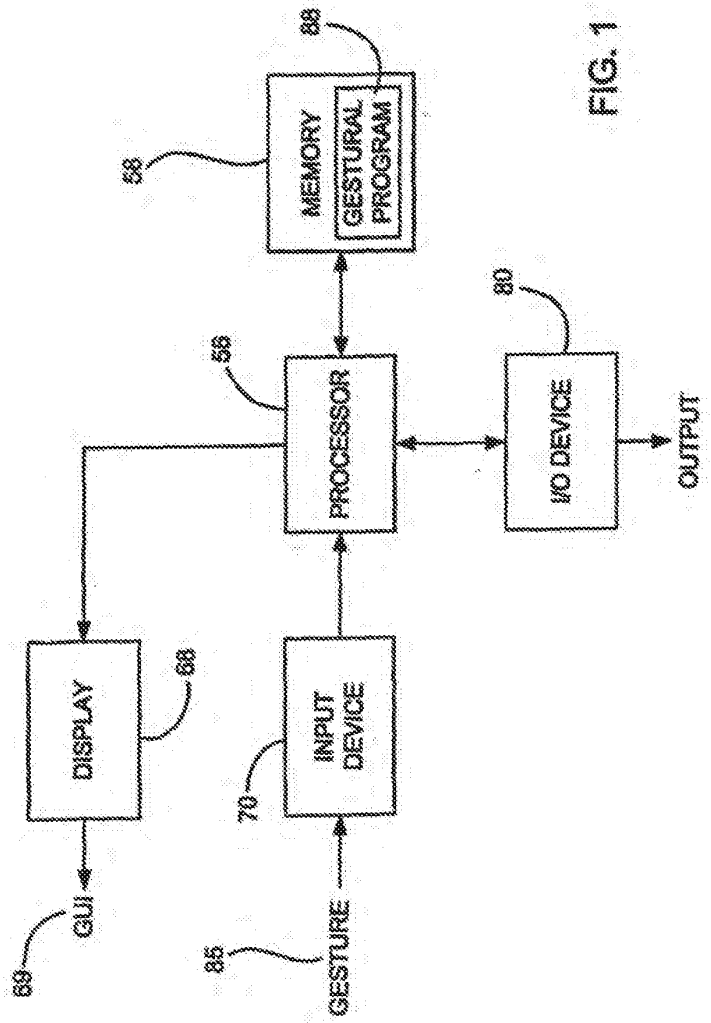

88
MEMORY
GESTURAL PROGRAM
68
80
58
PROCESSOR
I/O DEVICE
OUTPUT
DISPLAY
68
INPUT DEVICE
70
GUI
69
85
GESTURE

FIG. 1

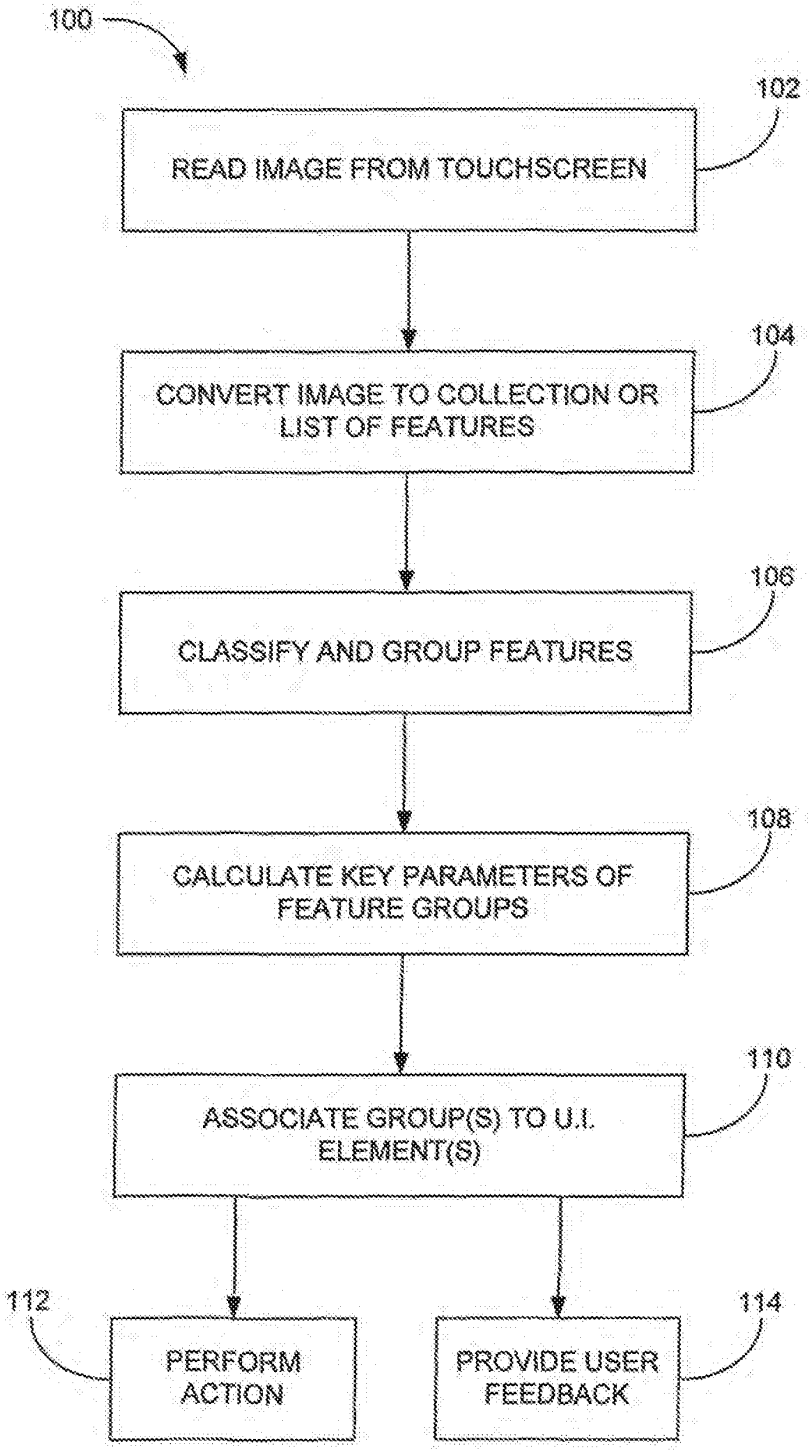

100
102
READ IMAGE FROM TOUCHSCREEN
104
CONVERT IMAGE TO COLLECTION OR LIST OF FEATURES
106
CLASSIFY AND GROUP FEATURES
108
CALCULATE KEY PARAMETERS OF FEATURE GROUPS
110
ASSOCIATE GROUP(S) TO U.I. ELEMENT(S)
112
PERFORM ACTION
114
PROVIDE USER FEEDBACK

FIG. 2

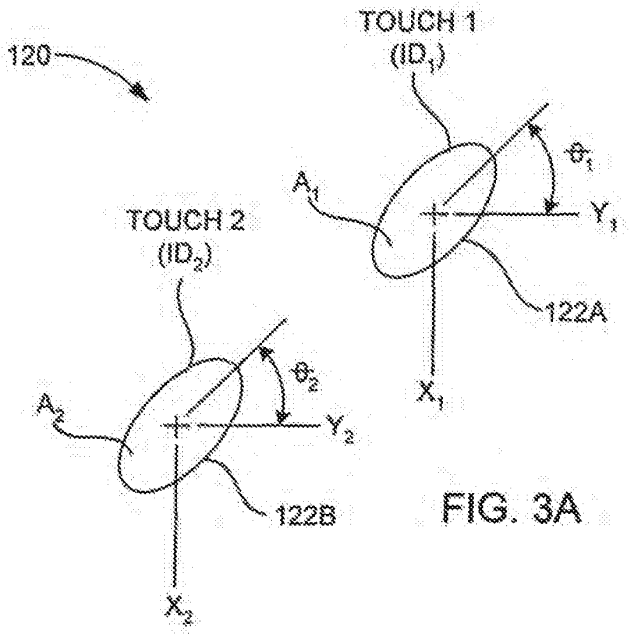

120
TOUCH 1
(ID1)
θ1
A1
Y1
TOUCH 2
(ID2)
122A
θ2
A2
Y2
X1
122B
X2

FIG. 3A

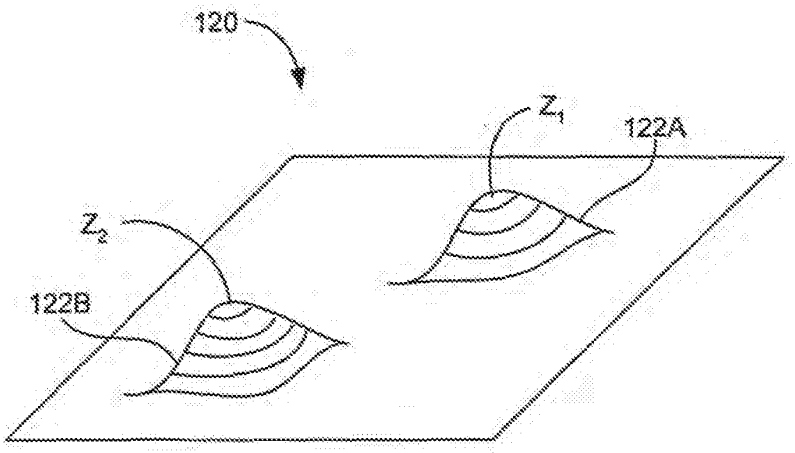

120
Z1
122A
Z2
122B

FIG. 3B

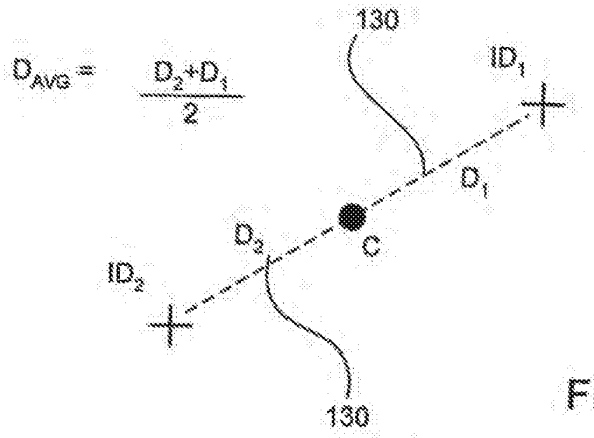


FIG. 4

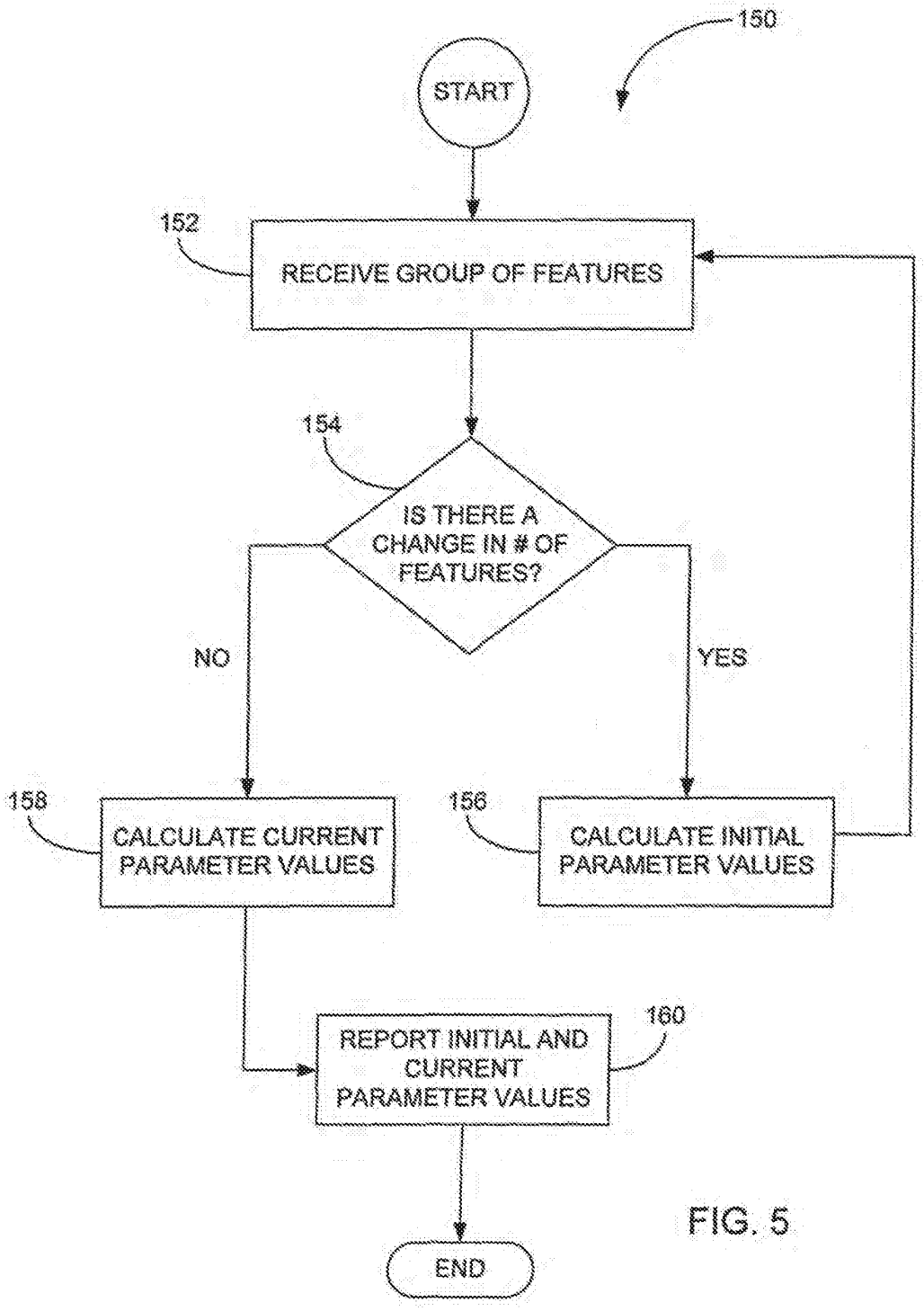

150
START
152
RECEIVE GROUP OF FEATURES
154
IS THERE A CHANGE IN # OF FEATURES?
NO
YES
158
CALCULATE CURRENT PARAMETER VALUES
156
CALCULATE INITIAL PARAMETER VALUES
160
REPORT INITIAL AND CURRENT PARAMETER VALUES
END

FIG. 5

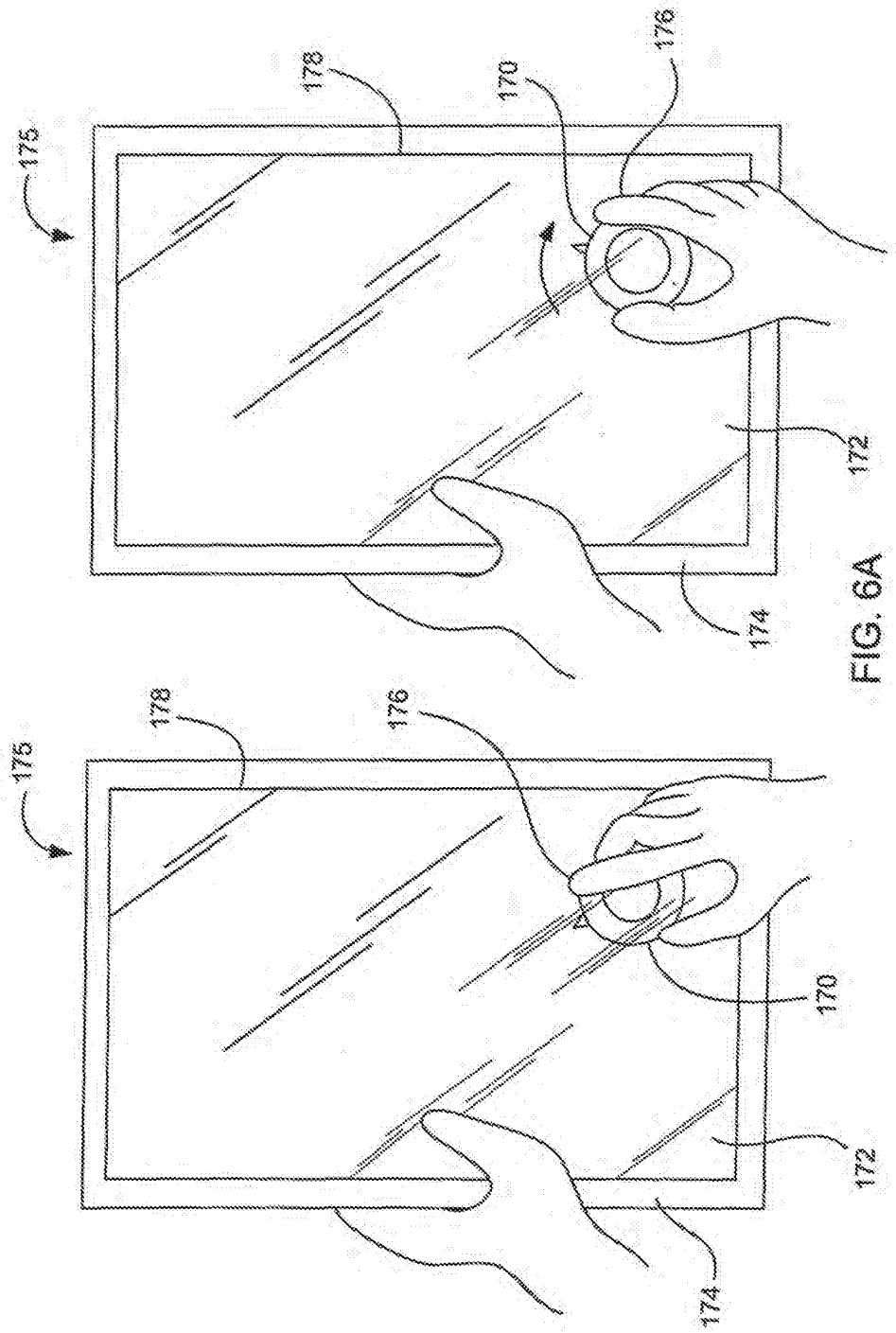


FIG. 6A

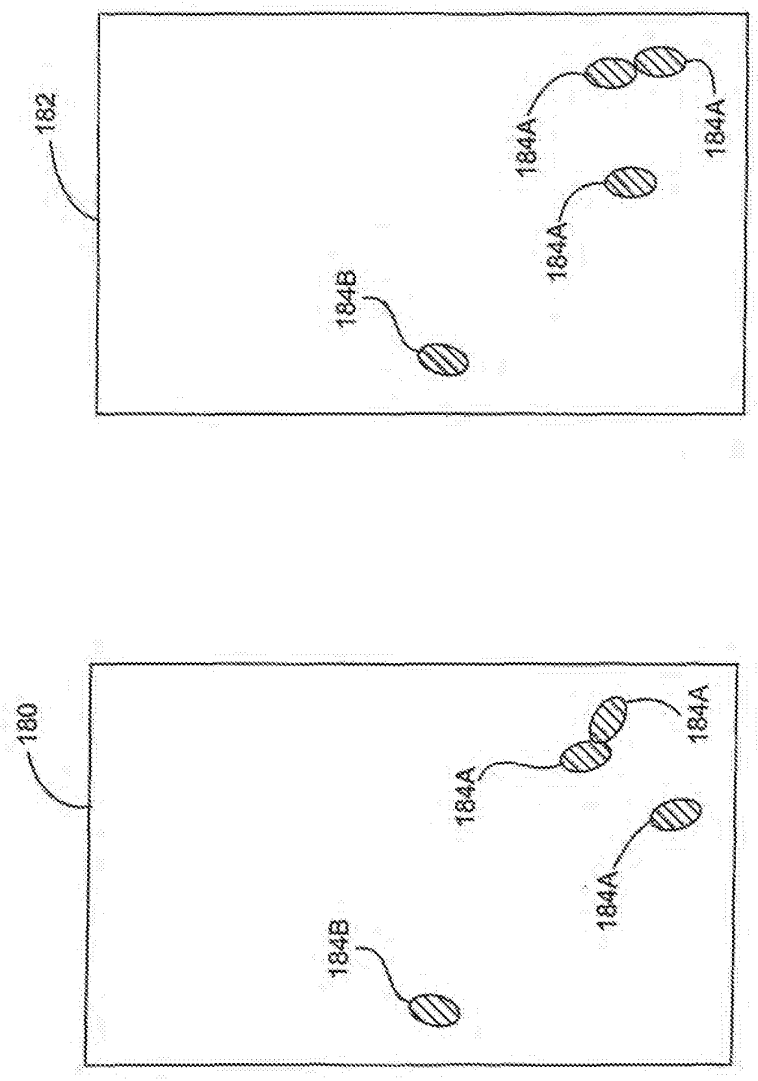


FIG. 6B

EX1002 - Page 963

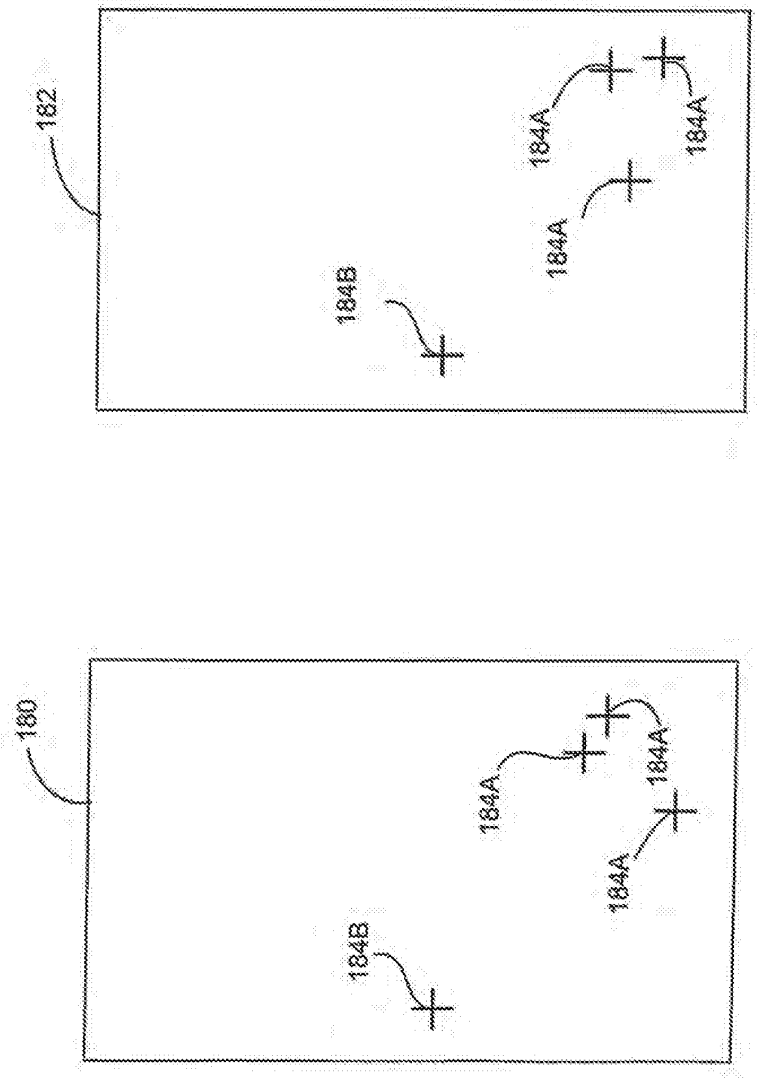


FIG. 6C

EX1002 - Page 964

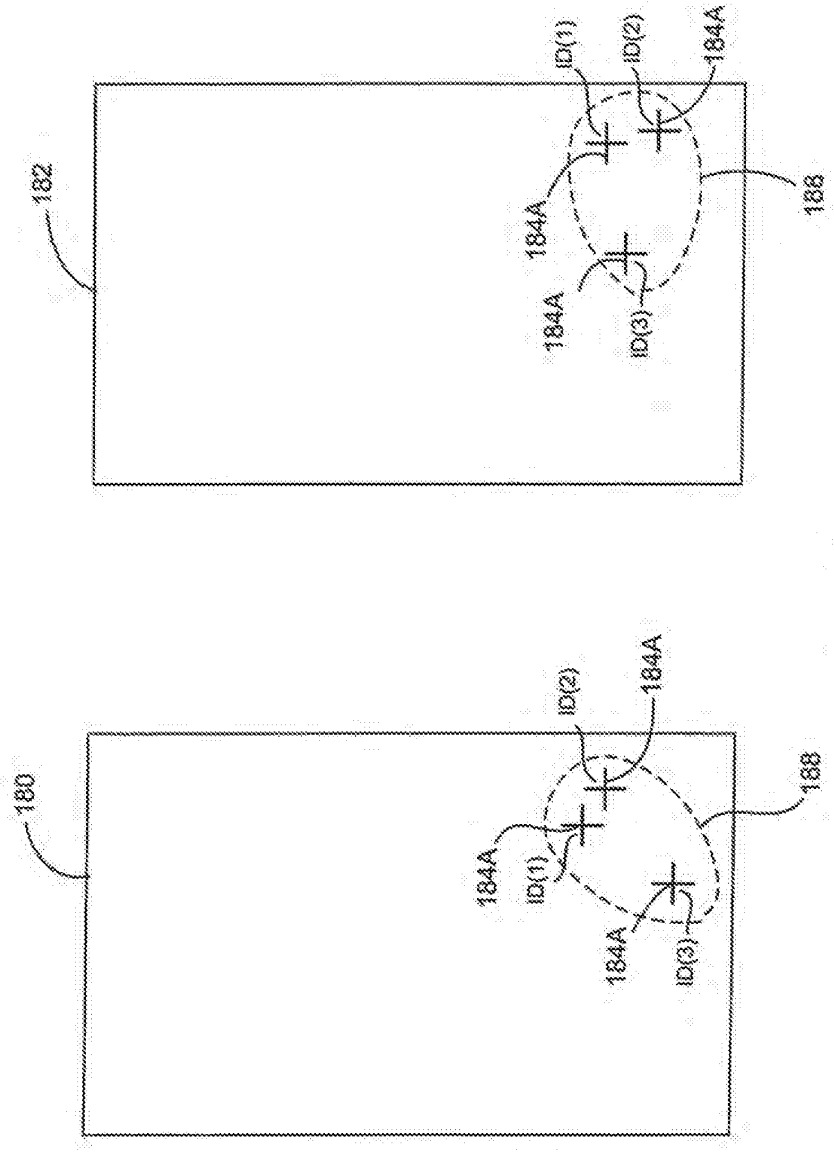


FIG. 6D

EX1002 - Page 965

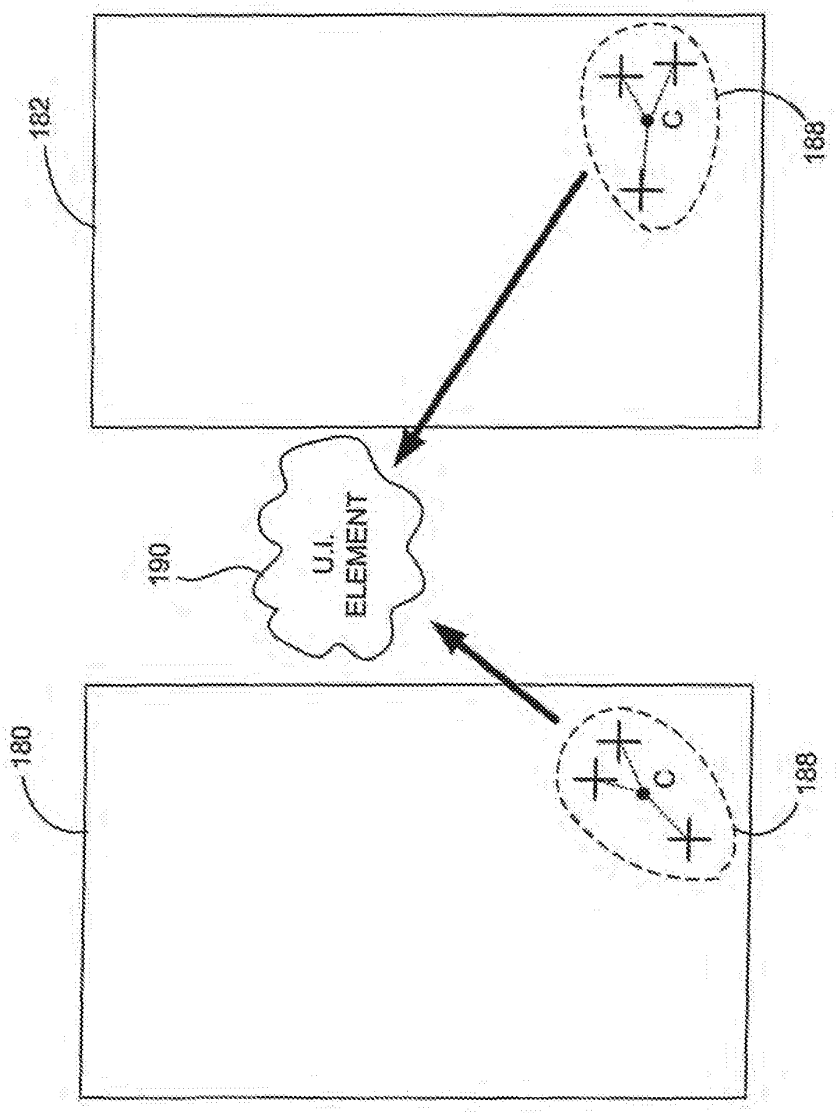


FIG. 6E

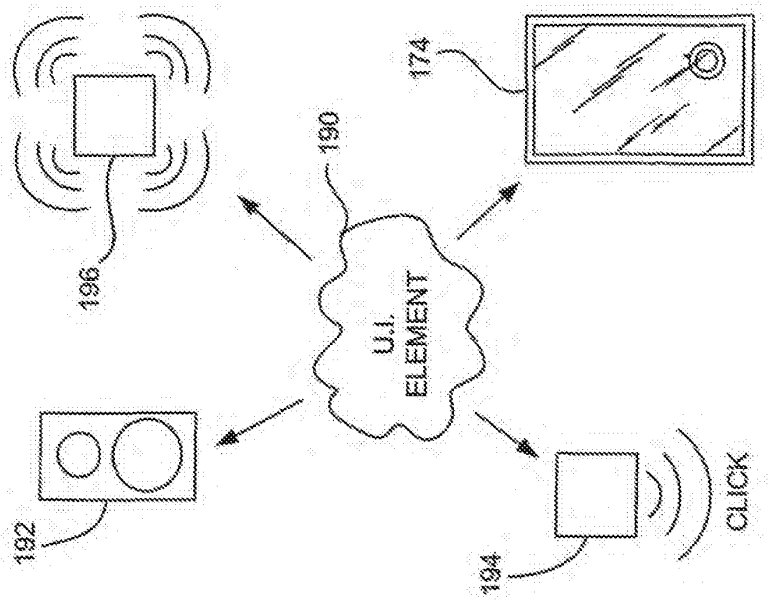


FIG. 6G

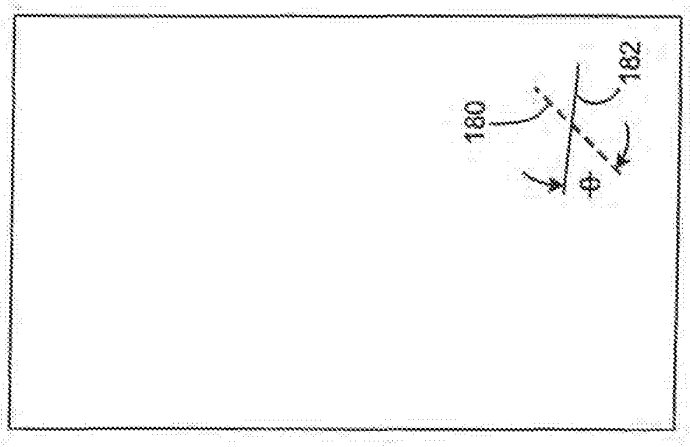


FIG. 6F

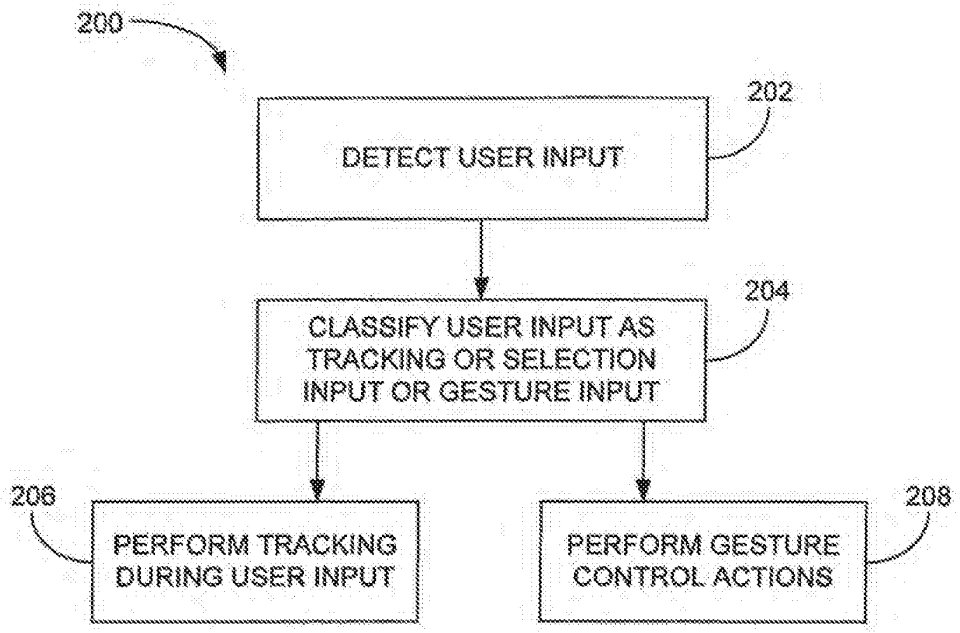

200
DETECT USER INPUT
202
CLASSIFY USER INPUT AS TRACKING OR SELECTION INPUT OR GESTURE INPUT
204
206
PERFORM TRACKING DURING USER INPUT
PERFORM GESTURE CONTROL ACTIONS
208

FIG. 7

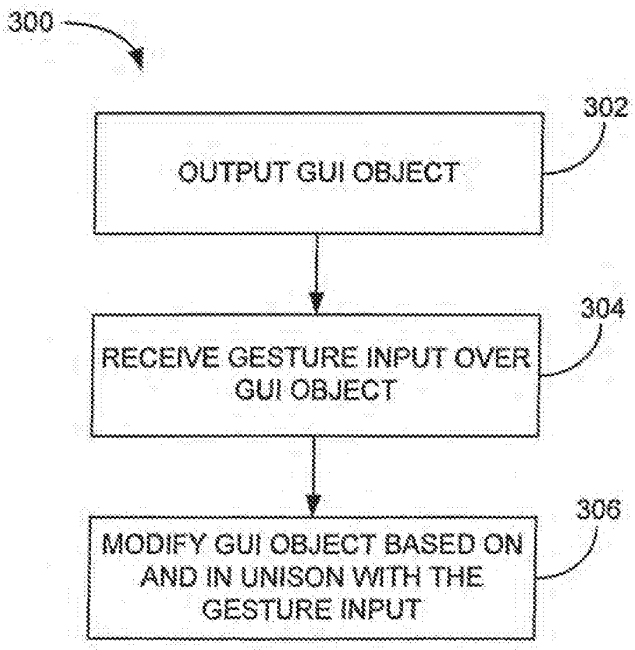

300
OUTPUT GUI OBJECT
302
RECEIVE GESTURE INPUT OVER GUI OBJECT
304
MODIFY GUI OBJECT BASED ON AND IN UNISON WITH THE GESTURE INPUT
306

FIG. 9

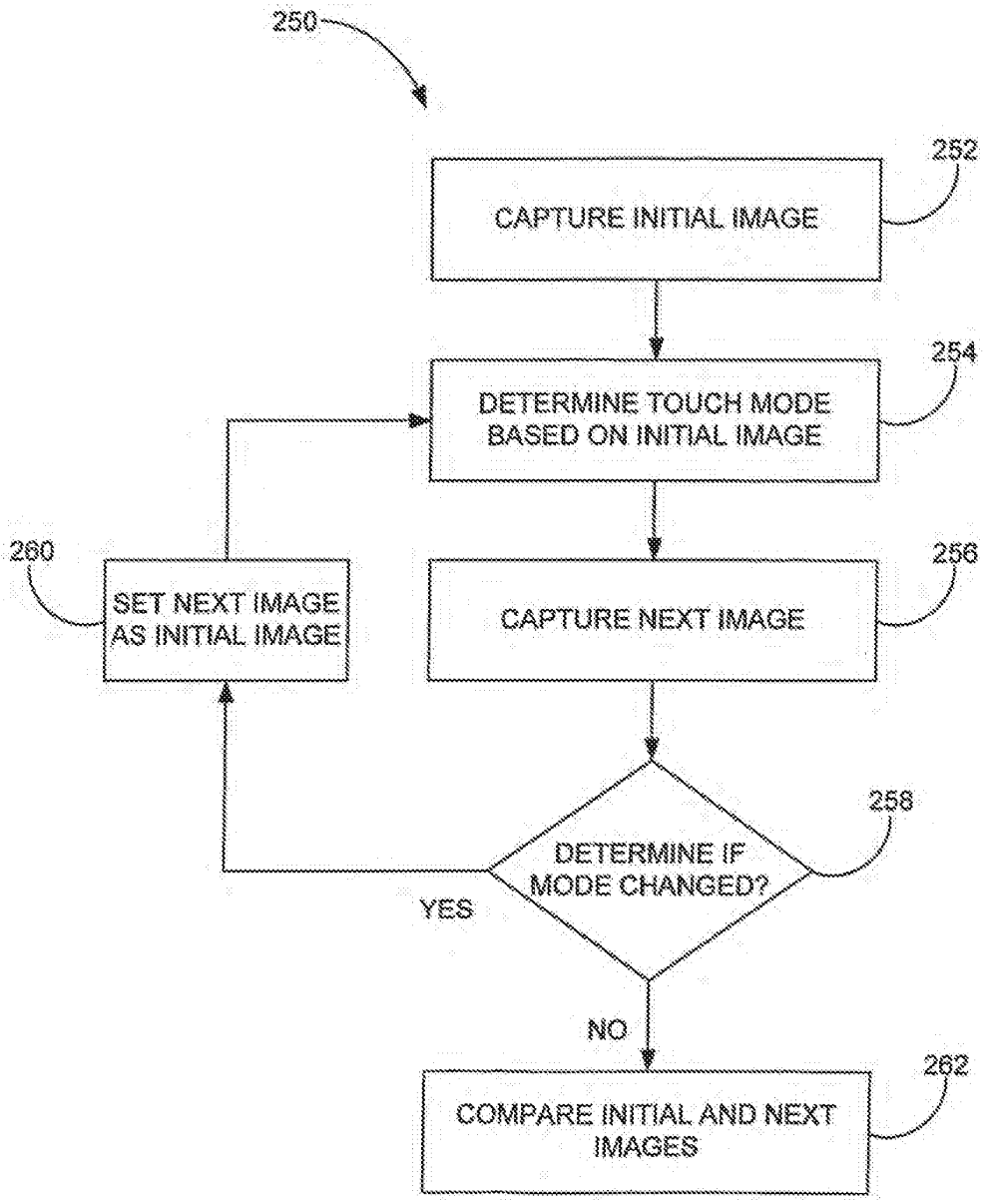

250
252
CAPTURE INITIAL IMAGE
254
DETERMINE TOUCH MODE BASED ON INITIAL IMAGE
256
CAPTURE NEXT IMAGE
258
DETERMINE IF MODE CHANGED?
YES
NO
260
SET NEXT IMAGE AS INITIAL IMAGE
262
COMPARE INITIAL AND NEXT IMAGES

FIG. 8

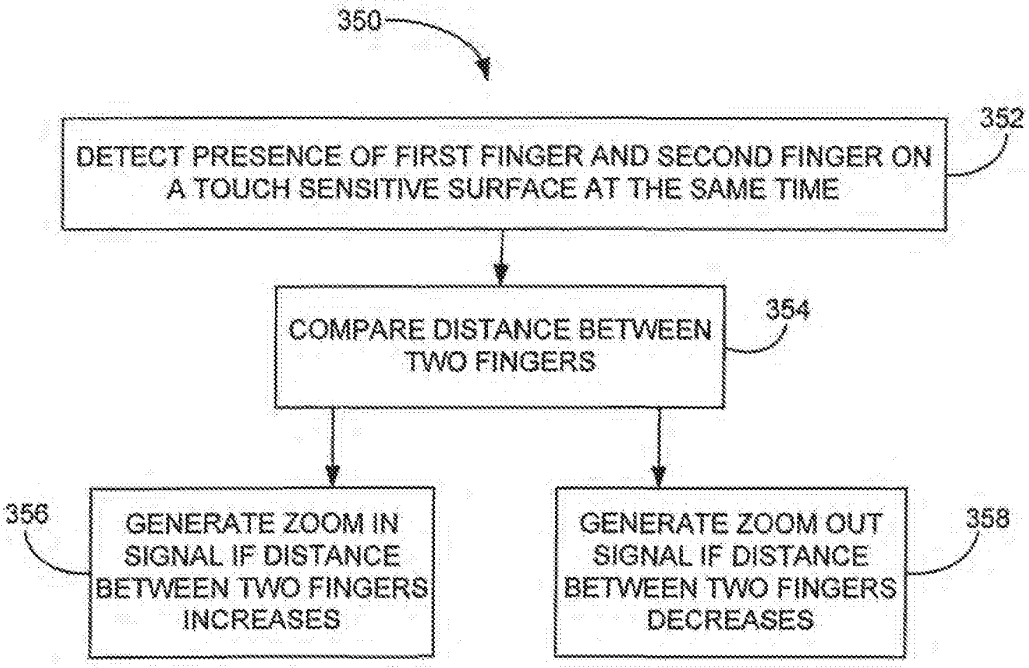

350
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
352
COMPARE DISTANCE BETWEEN TWO FINGERS
354
GENERATE ZOOM IN SIGNAL IF DISTANCE BETWEEN TWO FINGERS INCREASES
356
GENERATE ZOOM OUT SIGNAL IF DISTANCE BETWEEN TWO FINGERS DECREASES
358

FIG. 10

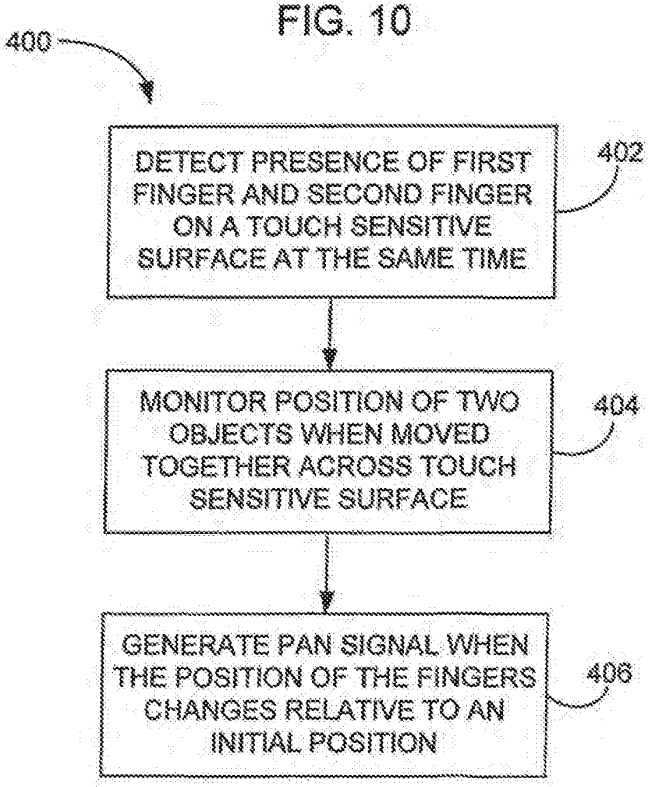

400
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
402
MONITOR POSITION OF TWO OBJECTS WHEN MOVED TOGETHER ACROSS TOUCH SENSITIVE SURFACE
404
GENERATE PAN SIGNAL WHEN THE POSITION OF THE FINGERS CHANGES RELATIVE TO AN INITIAL POSITION
406

FIG. 12

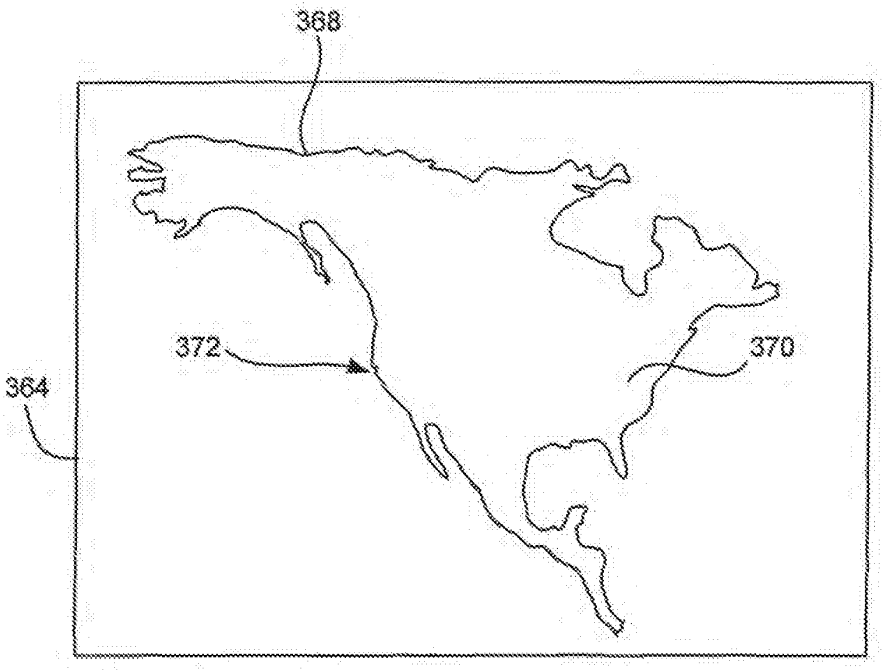


FIG. 11A

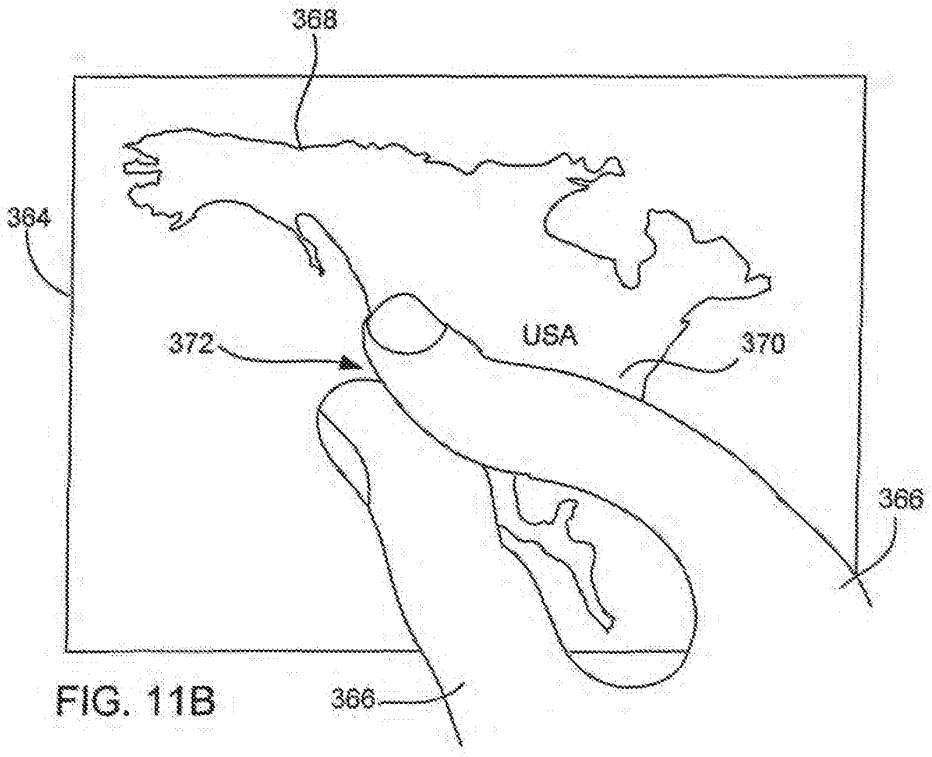


FIG. 11B

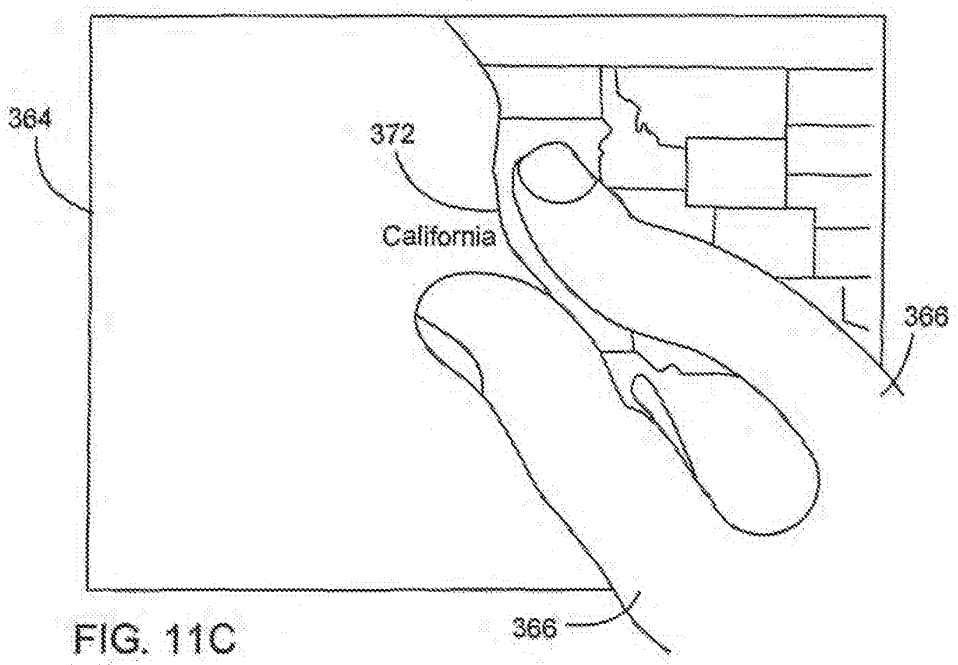


FIG. 11C

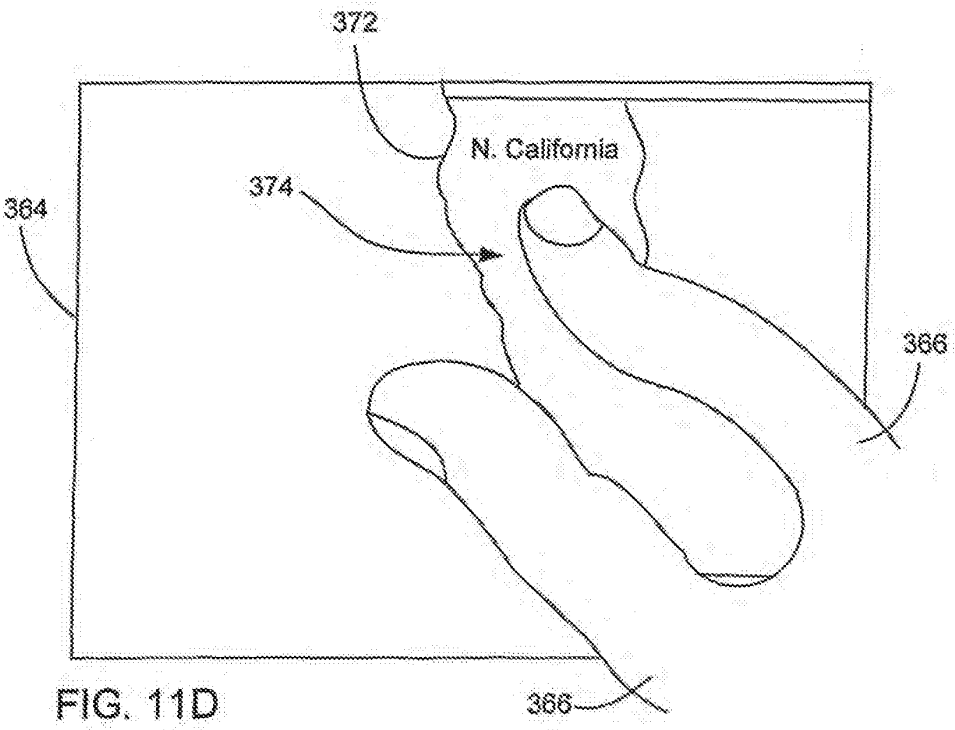


FIG. 11D

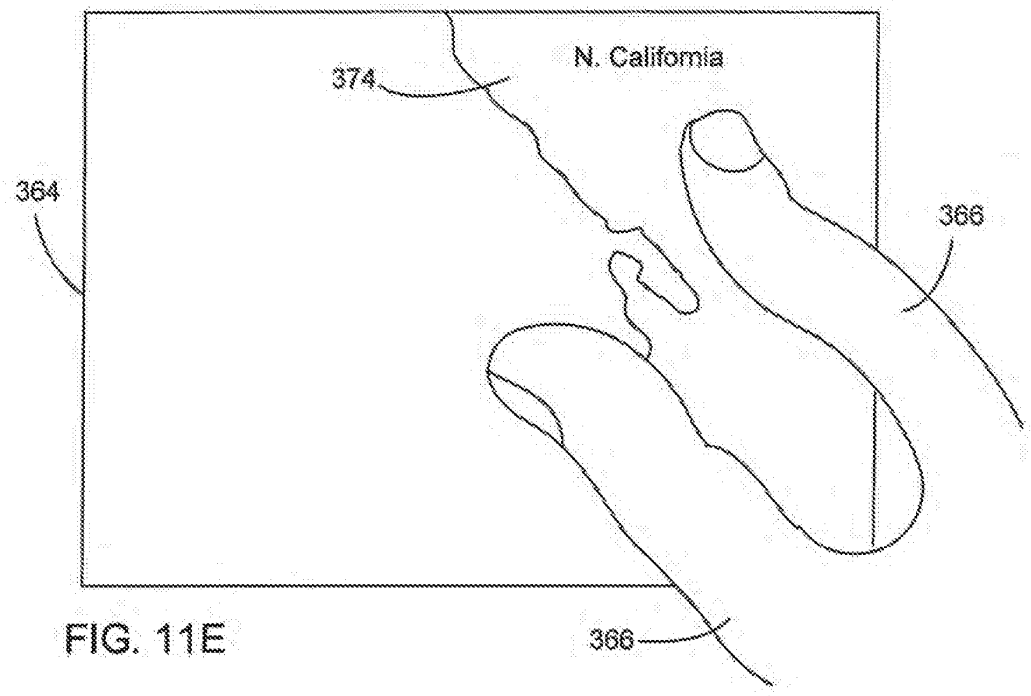


FIG. 11E

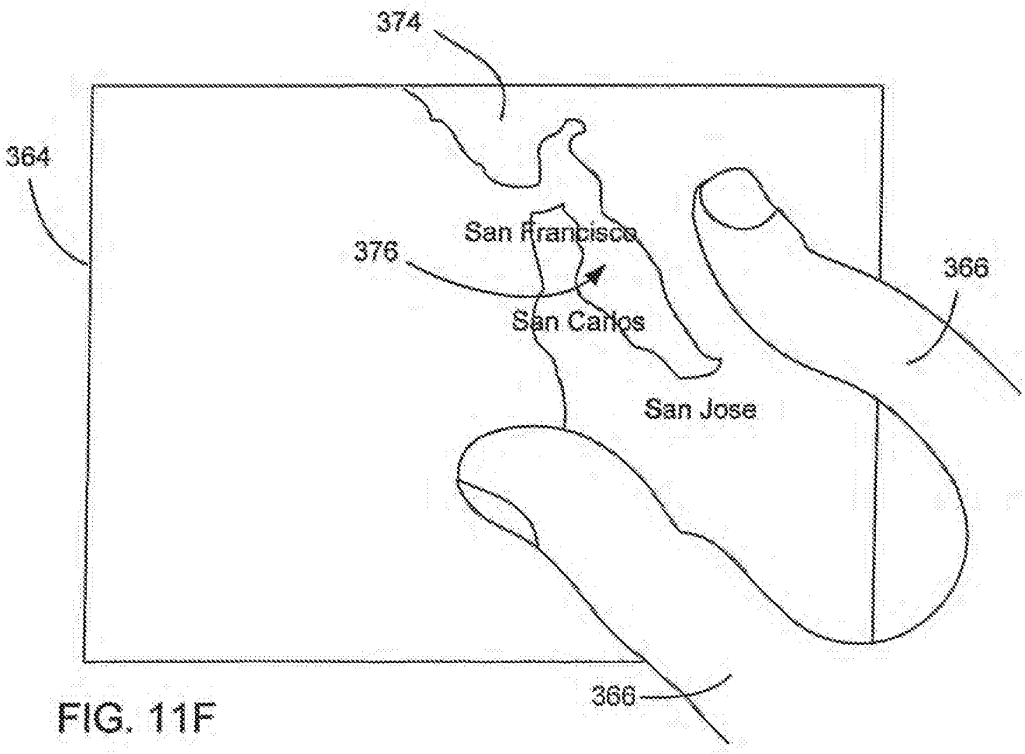


FIG. 11F

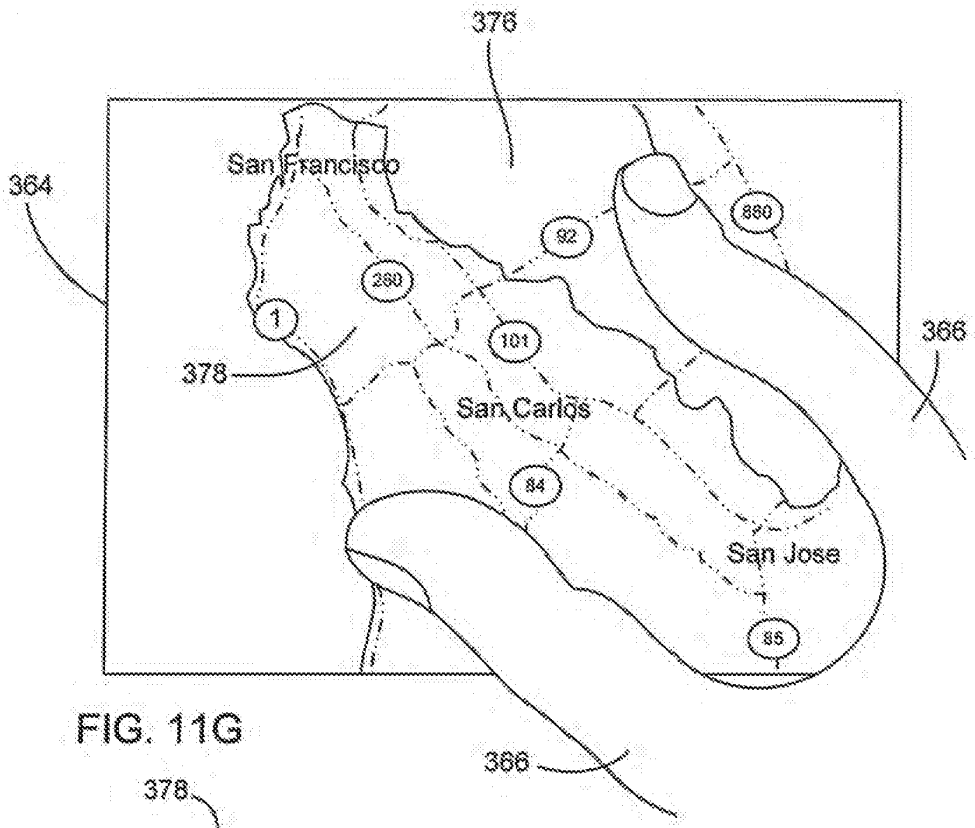


FIG. 11G

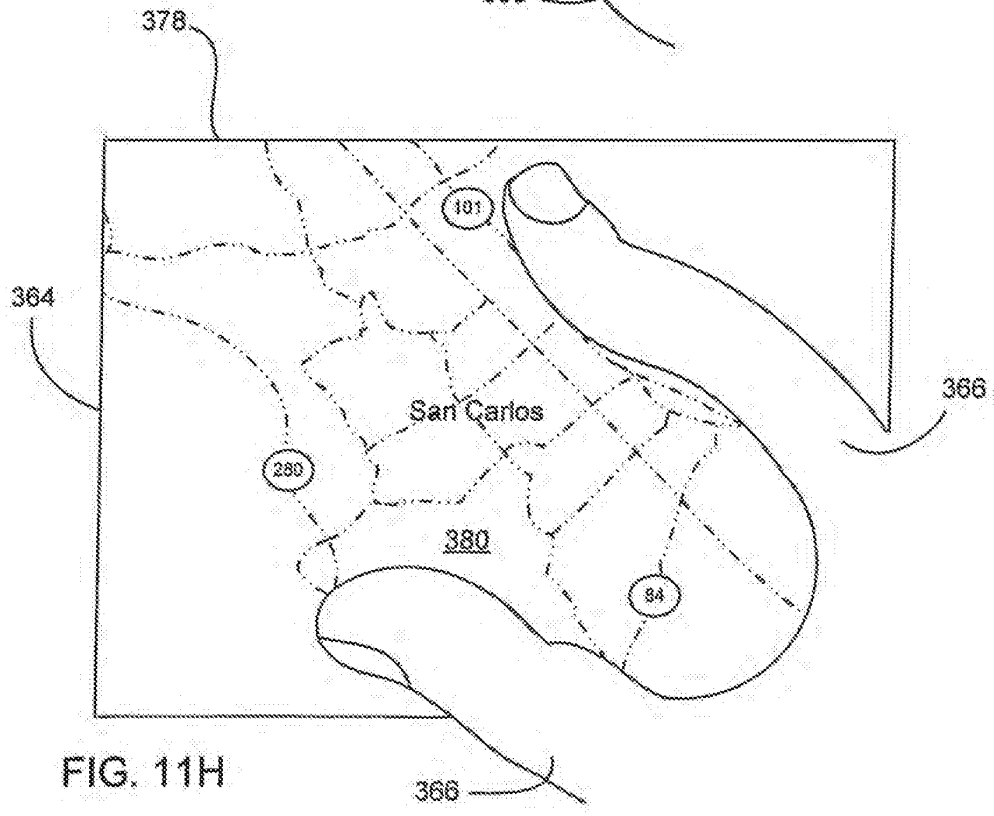


FIG. 11H

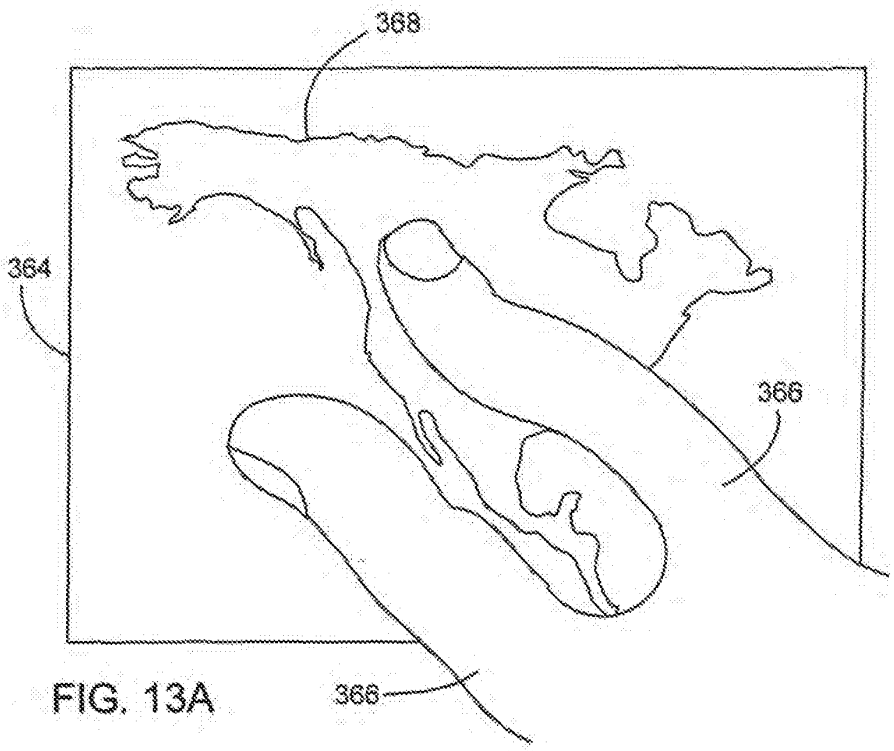


FIG. 13A

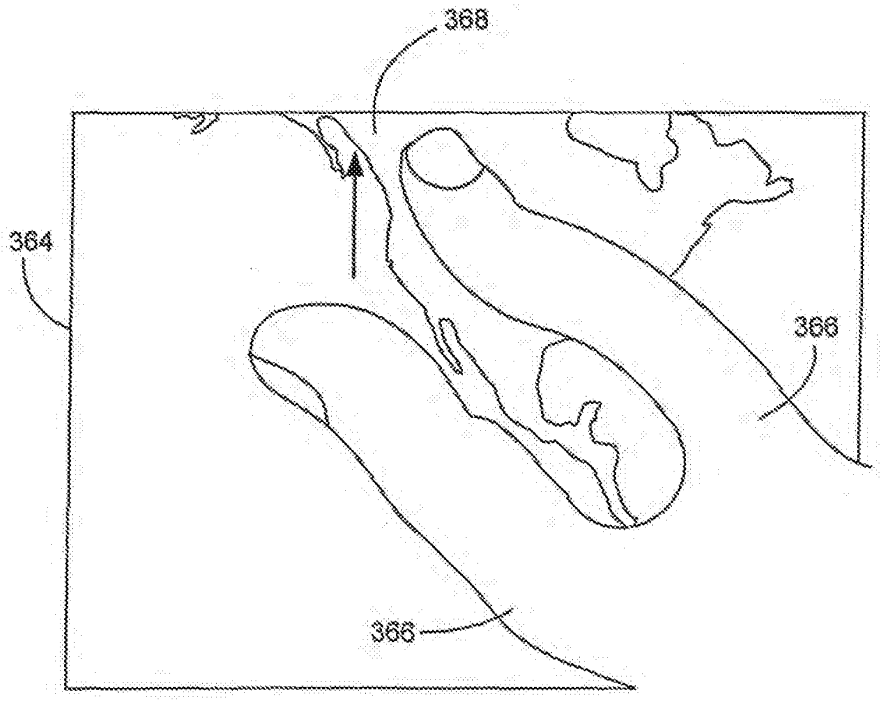


FIG. 13B

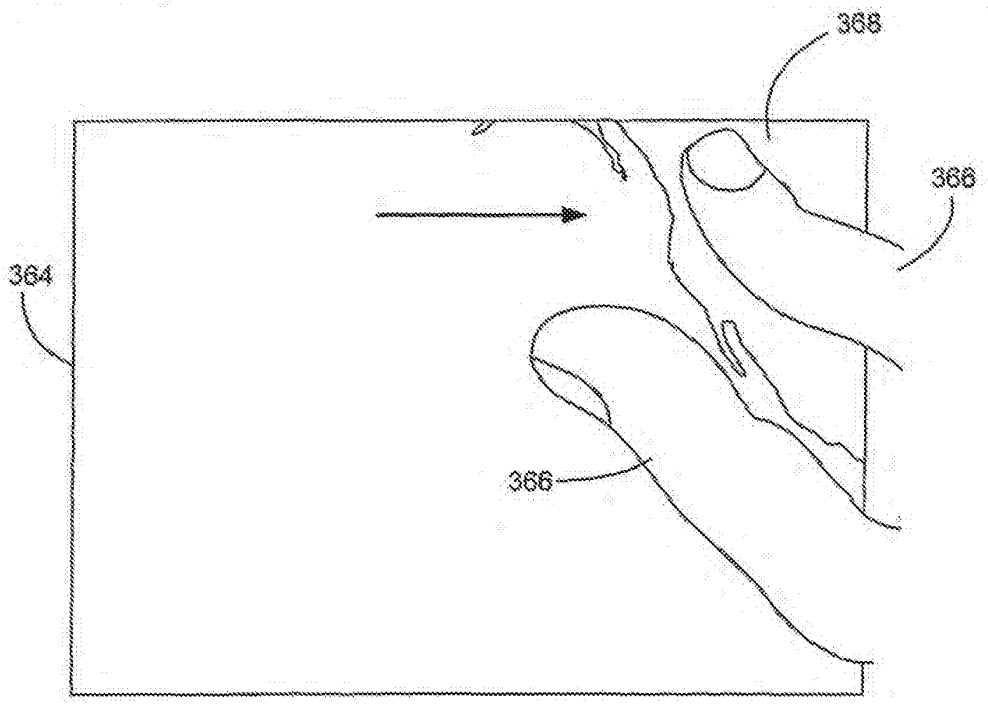


FIG. 13C

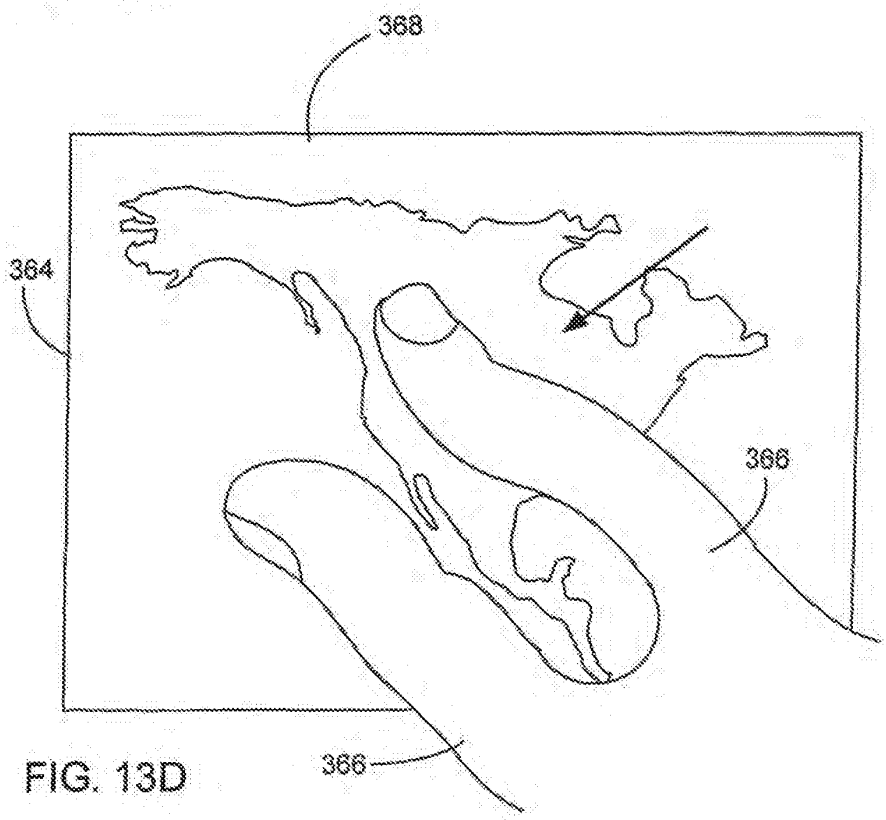


FIG. 13D

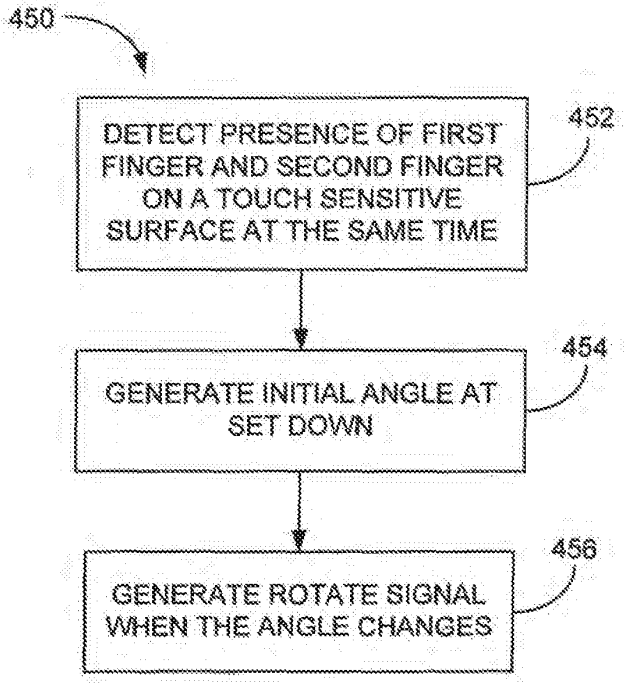

450
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
452
GENERATE INITIAL ANGLE AT SET DOWN
454
GENERATE ROTATE SIGNAL WHEN THE ANGLE CHANGES
456

FIG. 14

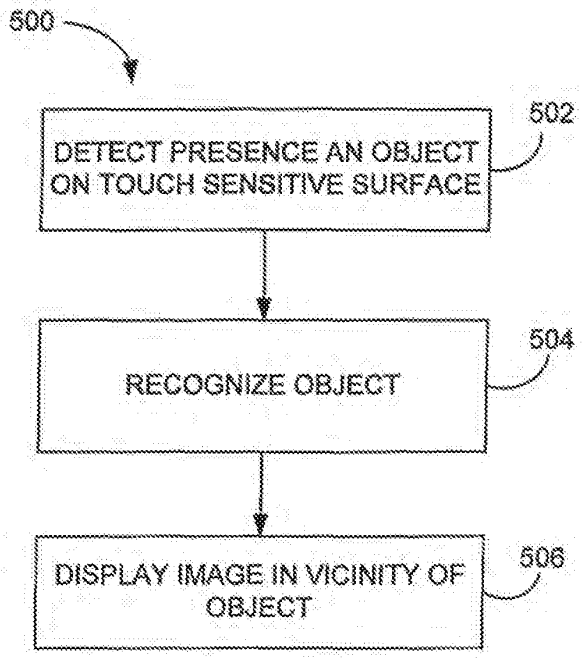

500
DETECT PRESENCE AN OBJECT ON TOUCH SENSITIVE SURFACE
502
RECOGNIZE OBJECT
504
DISPLAY IMAGE IN VICINITY OF OBJECT
506

FIG. 16

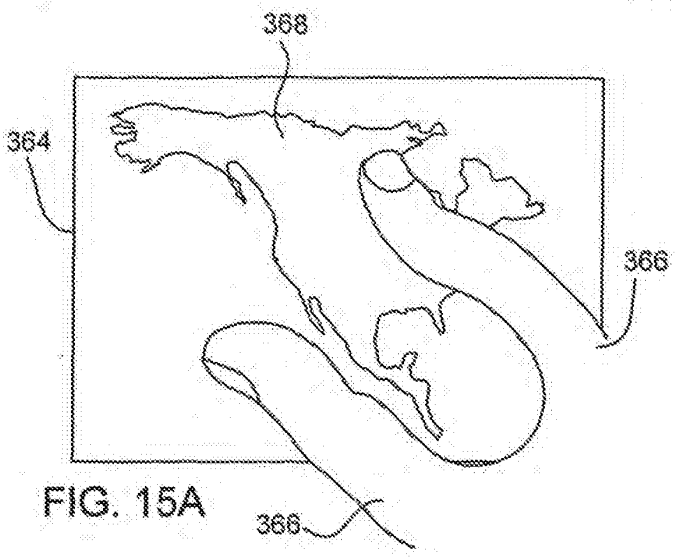


FIG. 15A

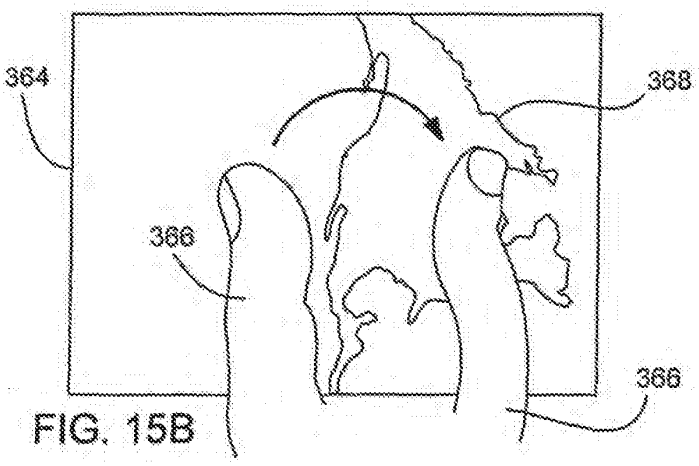


FIG. 15B

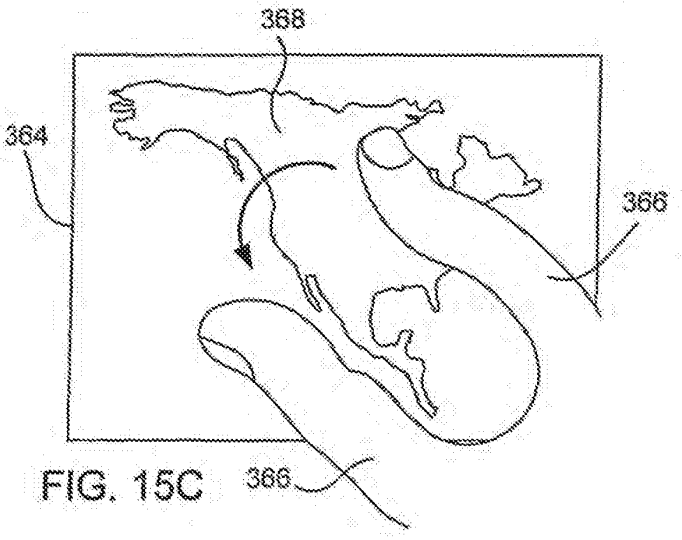


FIG. 15C

FIG. 17A

FIG. 17B

FIG. 17C

EX1002 - Page 979

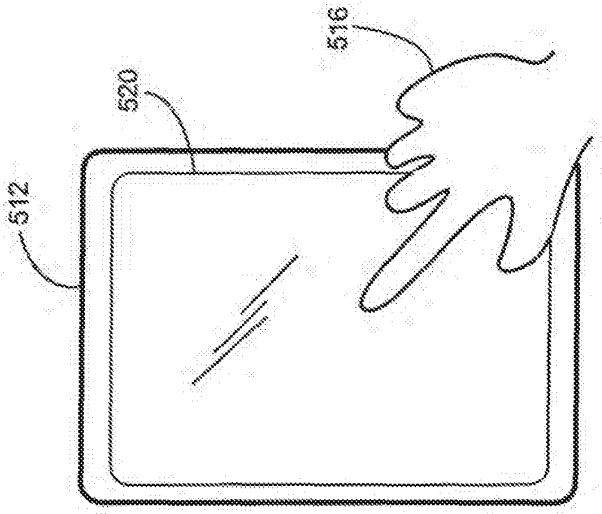


FIG. 17E

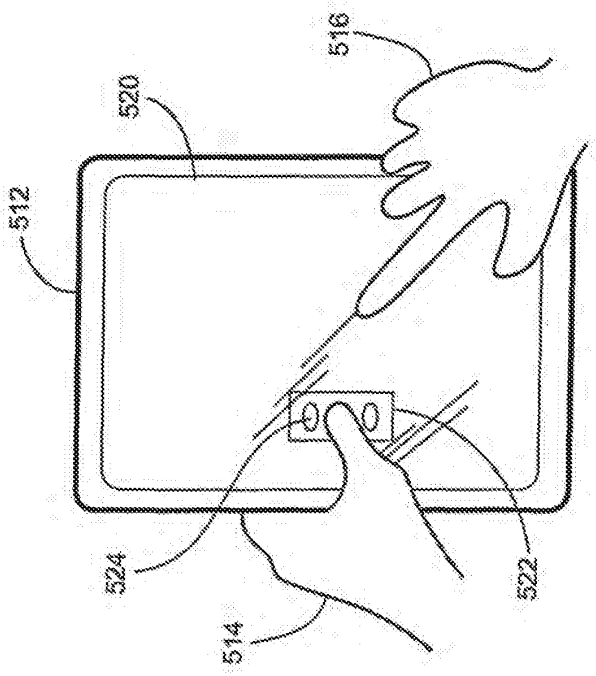


FIG. 17D

EX1002 - Page 980

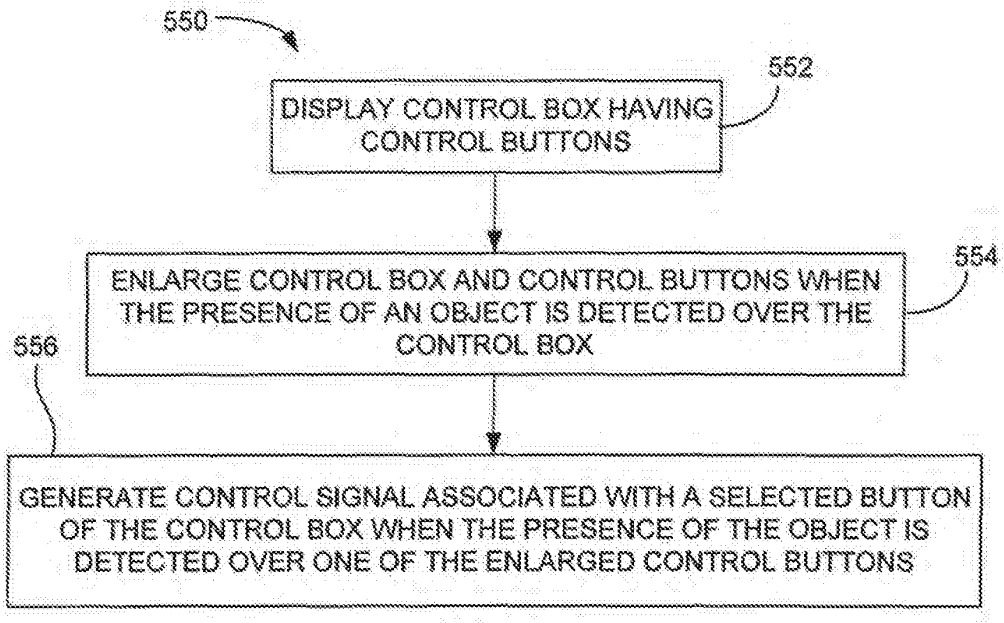

550
552
DISPLAY CONTROL BOX HAVING CONTROL BUTTONS
554
ENLARGE CONTROL BOX AND CONTROL BUTTONS WHEN THE PRESENCE OF AN OBJECT IS DETECTED OVER THE CONTROL BOX
556
GENERATE CONTROL SIGNAL ASSOCIATED WITH A SELECTED BUTTON OF THE CONTROL BOX WHEN THE PRESENCE OF THE OBJECT IS DETECTED OVER ONE OF THE ENLARGED CONTROL BUTTONS

FIG. 18

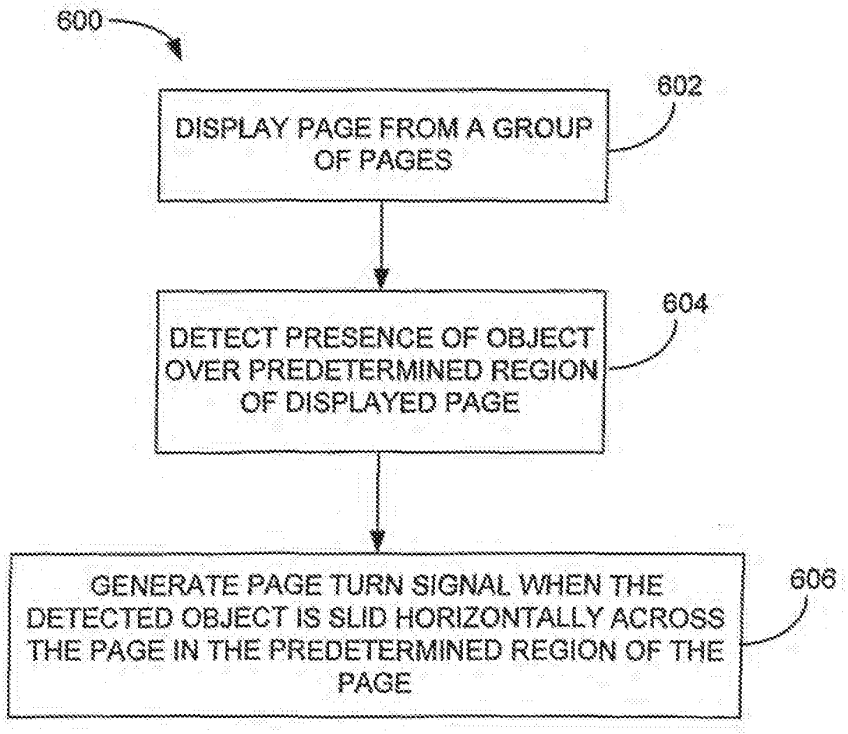

600
602
DISPLAY PAGE FROM A GROUP OF PAGES
604
DETECT PRESENCE OF OBJECT OVER PREDETERMINED REGION OF DISPLAYED PAGE
606
GENERATE PAGE TURN SIGNAL WHEN THE DETECTED OBJECT IS SLID HORIZONTALLY ACROSS THE PAGE IN THE PREDETERMINED REGION OF THE PAGE

FIG. 20

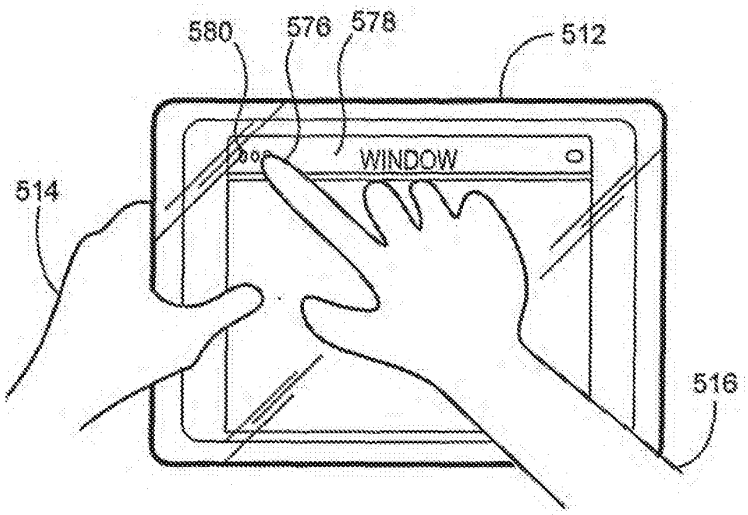


FIG. 19A

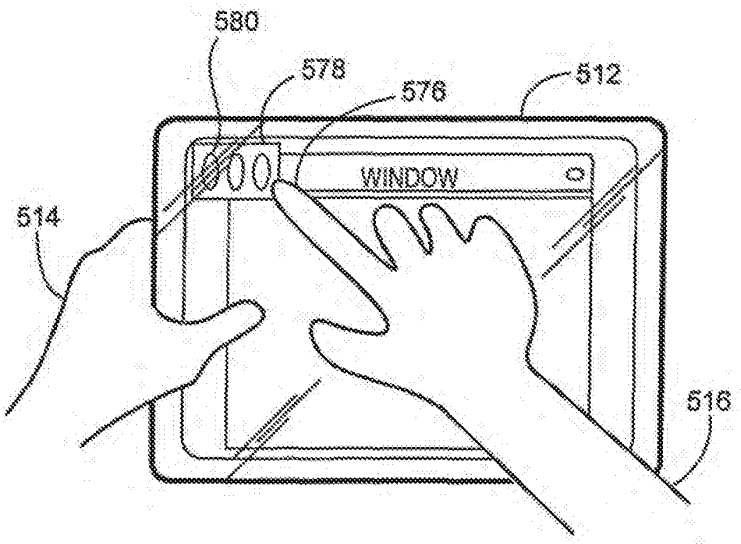


FIG. 19B

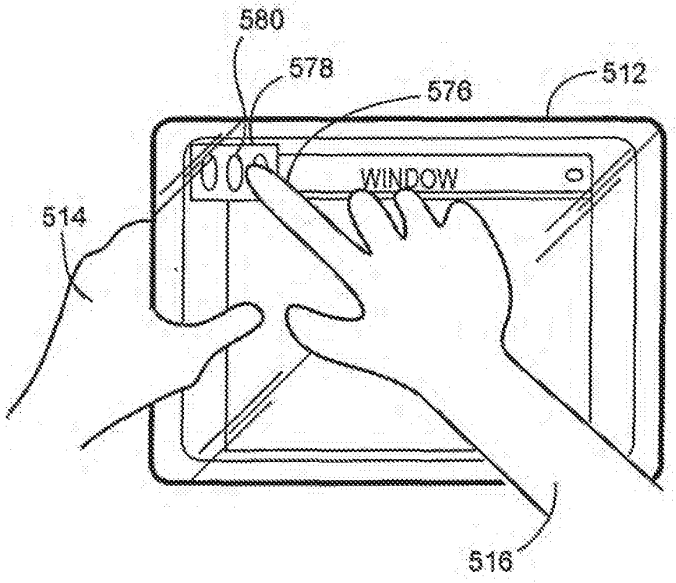


FIG. 19C

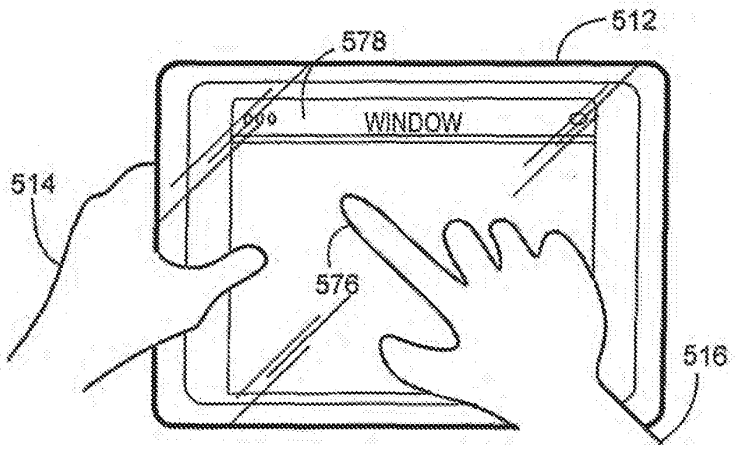


FIG. 19D

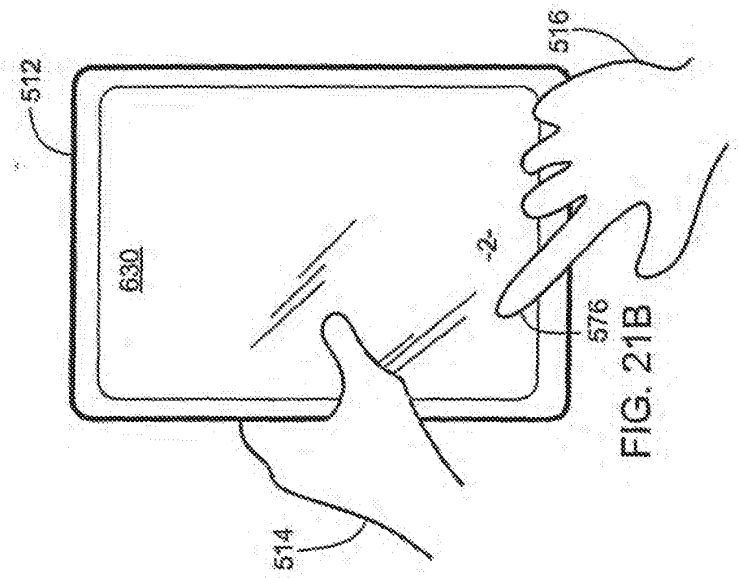


FIG. 21B

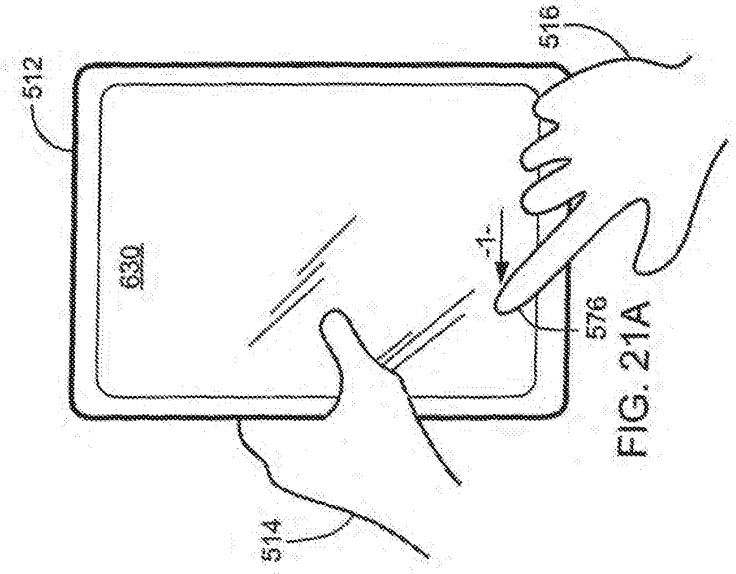


FIG. 21A

EX1002 - Page 984

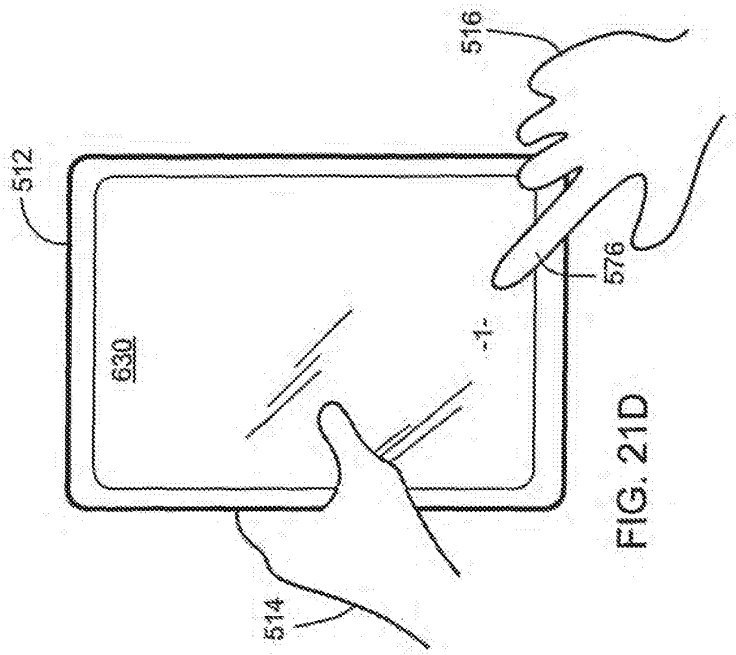


FIG. 21D

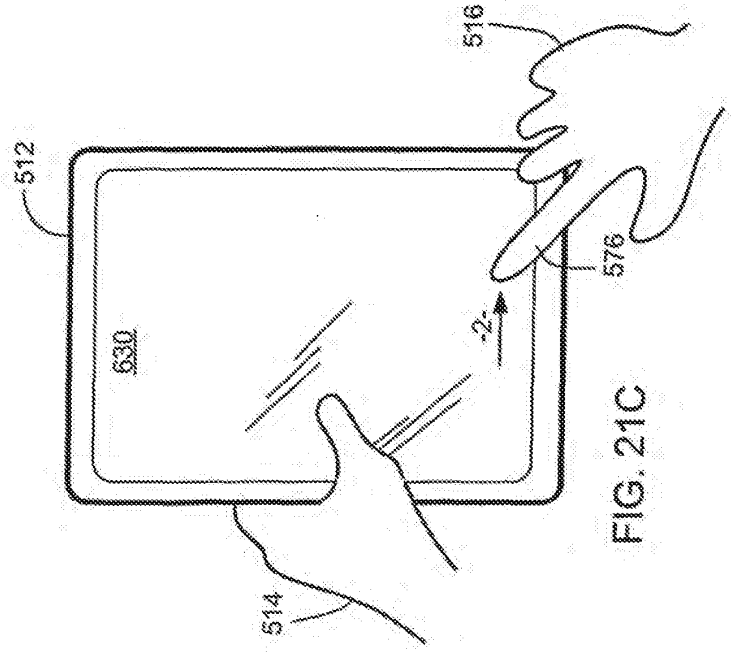


FIG. 21C

EX1002 - Page 985

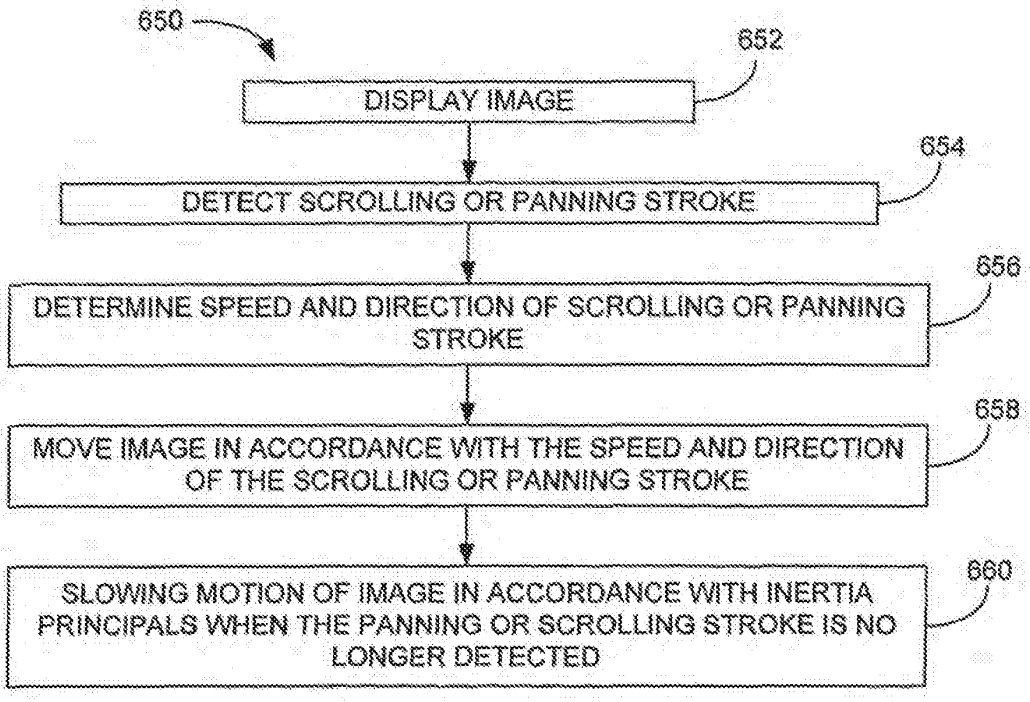

650
652
DISPLAY IMAGE
654
DETECT SCROLLING OR PANNING STROKE
656
DETERMINE SPEED AND DIRECTION OF SCROLLING OR PANNING STROKE
658
MOVE IMAGE IN ACCORDANCE WITH THE SPEED AND DIRECTION OF THE SCROLLING OR PANNING STROKE
660
SLOWING MOTION OF IMAGE IN ACCORDANCE WITH INERTIA PRINCIPALS WHEN THE PANNING OR SCROLLING STROKE IS NO LONGER DETECTED

FIG. 22

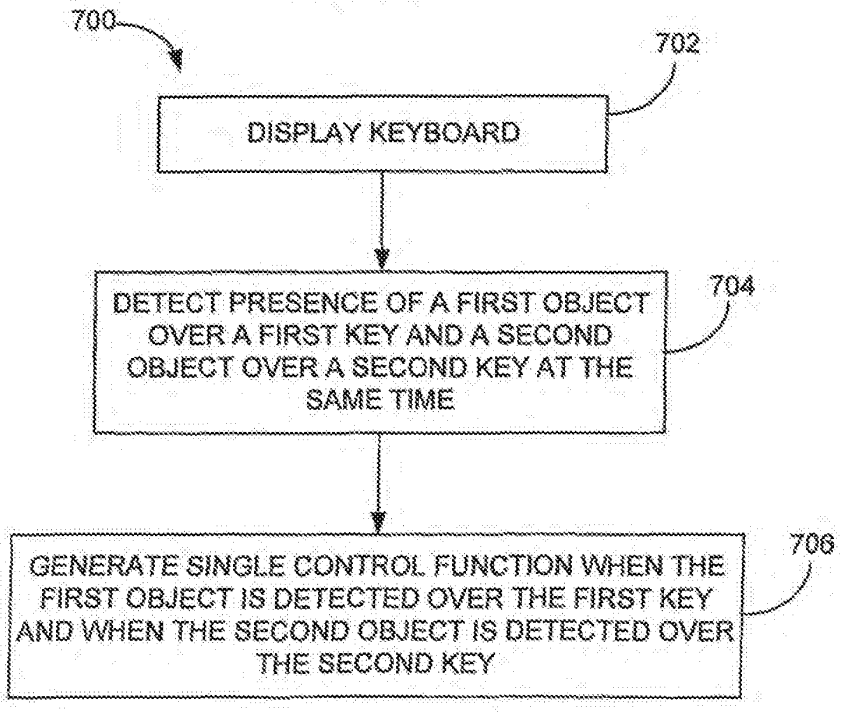

700
702
DISPLAY KEYBOARD
704
DETECT PRESENCE OF A FIRST OBJECT OVER A FIRST KEY AND A SECOND OBJECT OVER A SECOND KEY AT THE SAME TIME
706
GENERATE SINGLE CONTROL FUNCTION WHEN THE FIRST OBJECT IS DETECTED OVER THE FIRST KEY AND WHEN THE SECOND OBJECT IS DETECTED OVER THE SECOND KEY

FIG. 24

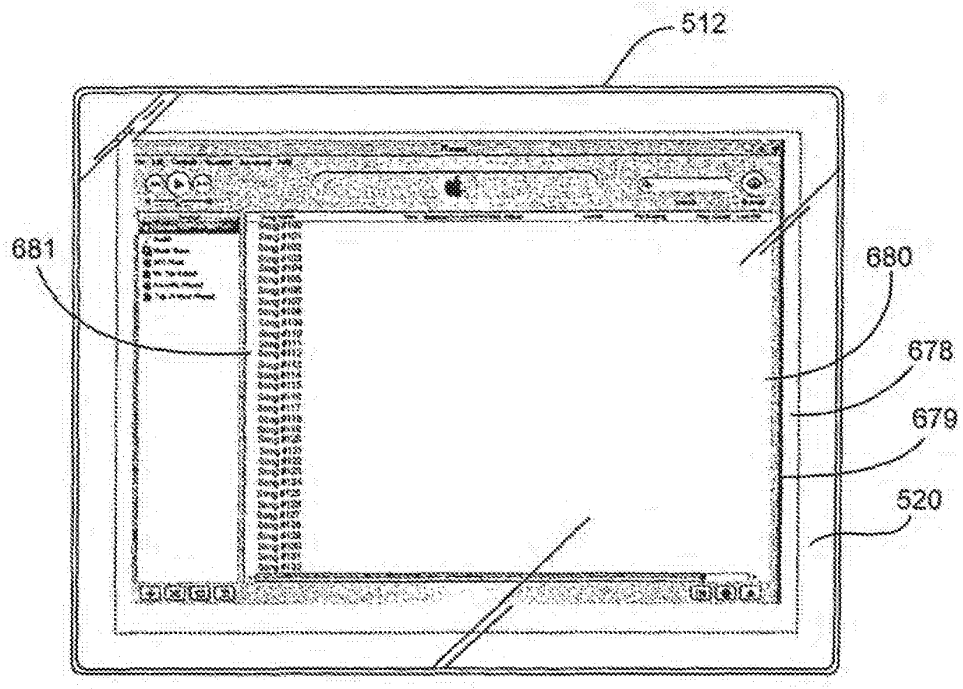


FIG. 23A

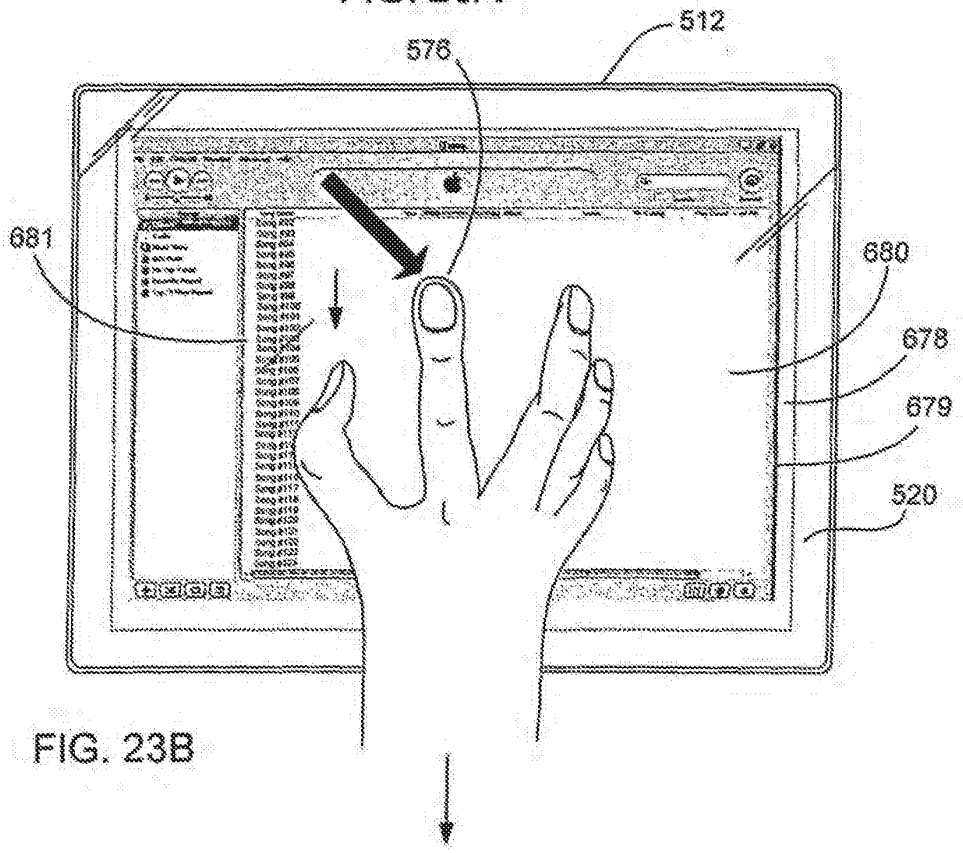


FIG. 23B

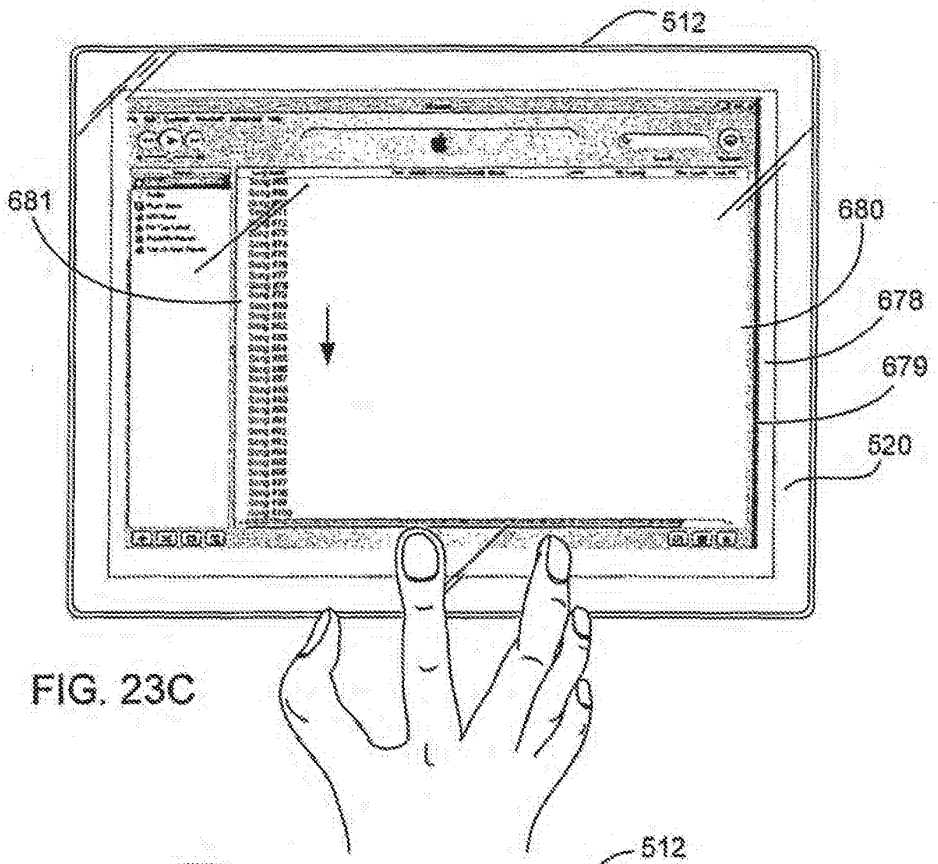


FIG. 23C

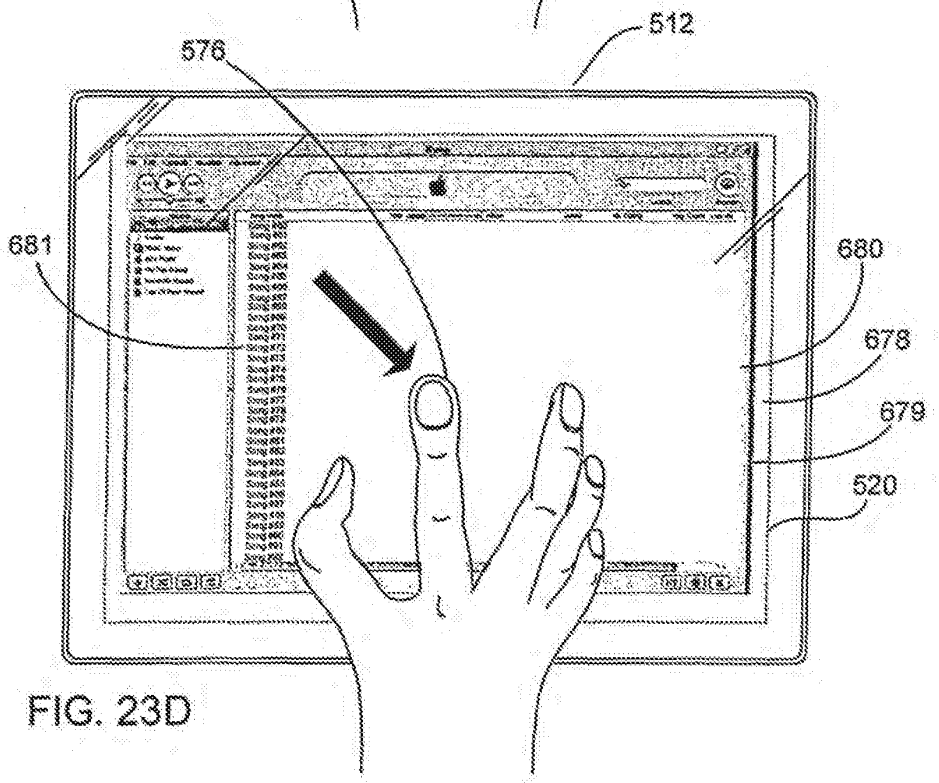


FIG. 23D

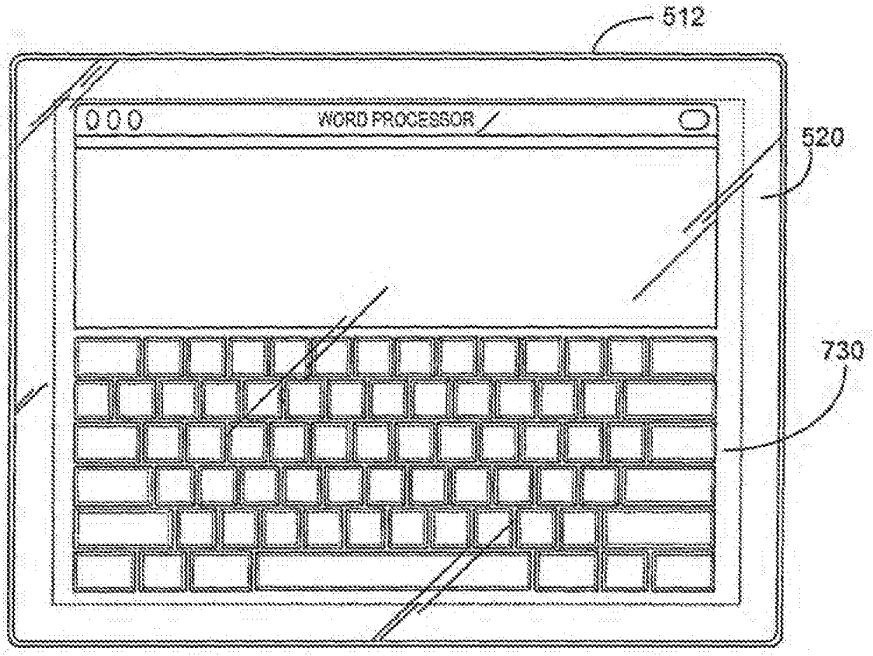


FIG. 25A

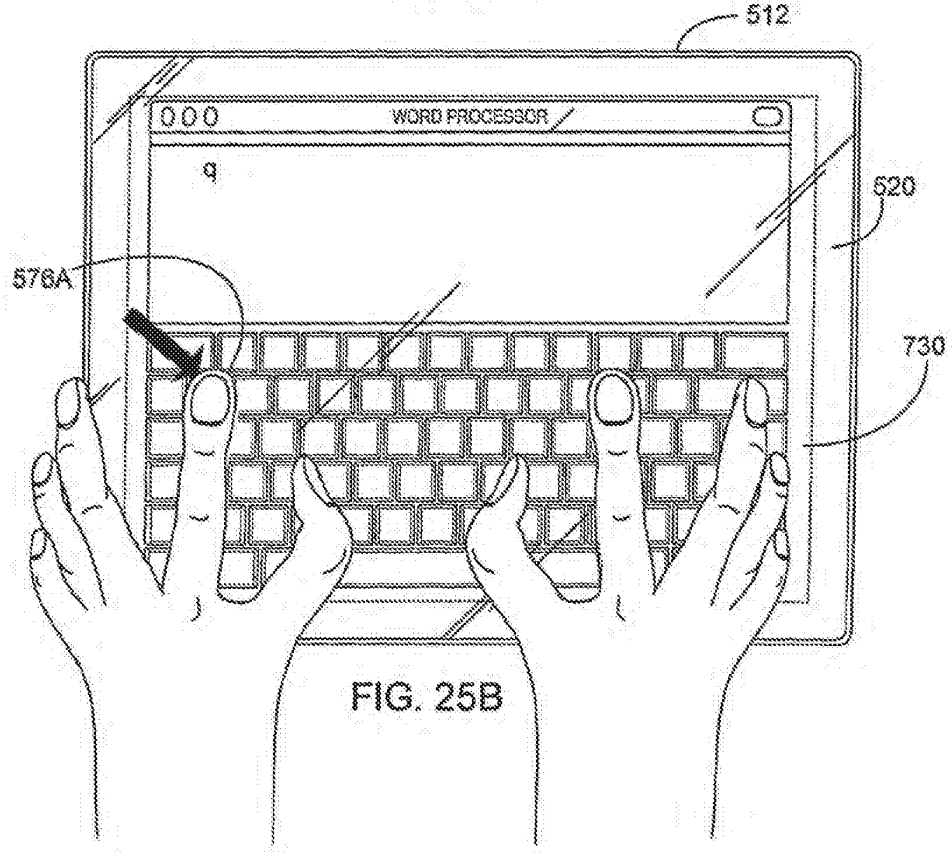


FIG. 25B

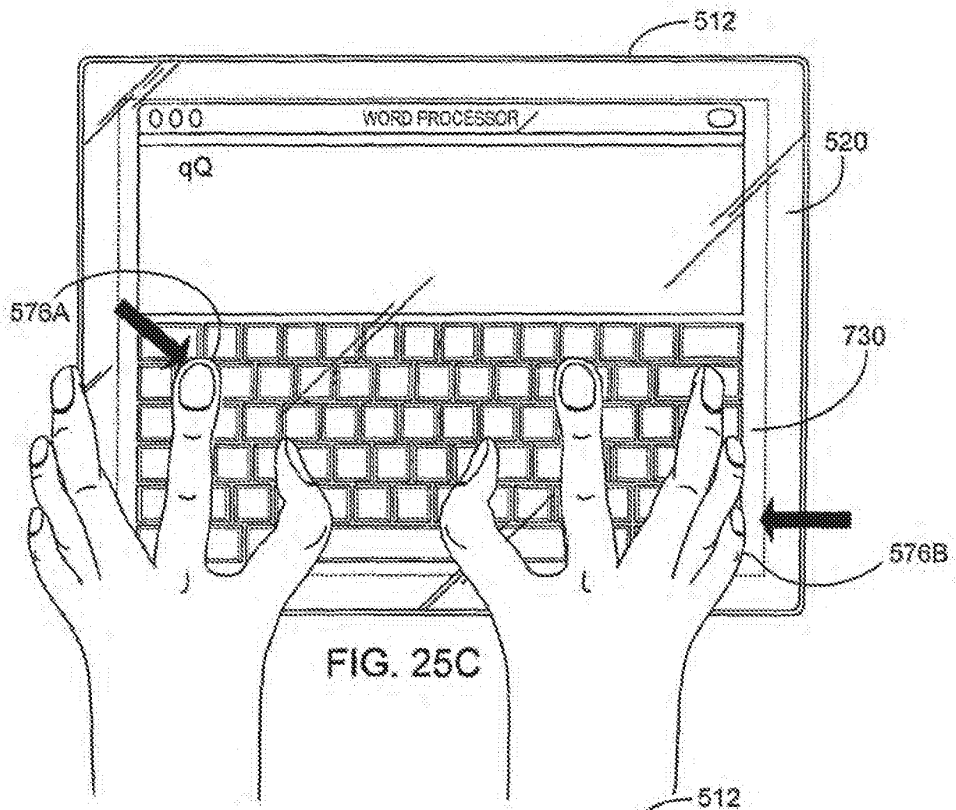


FIG. 25C

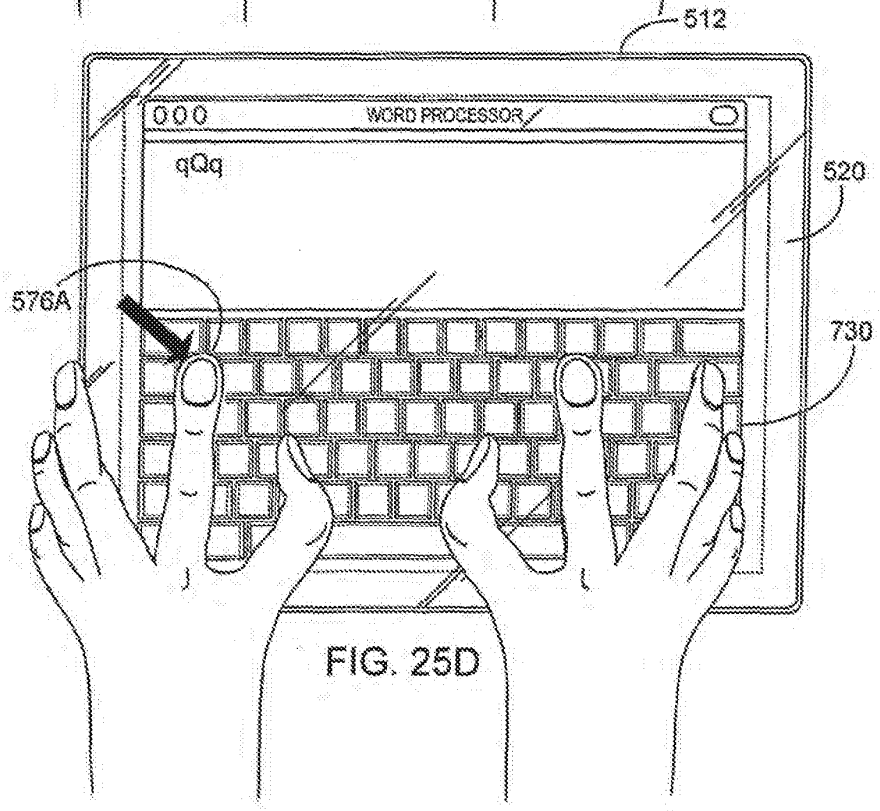


FIG. 25D

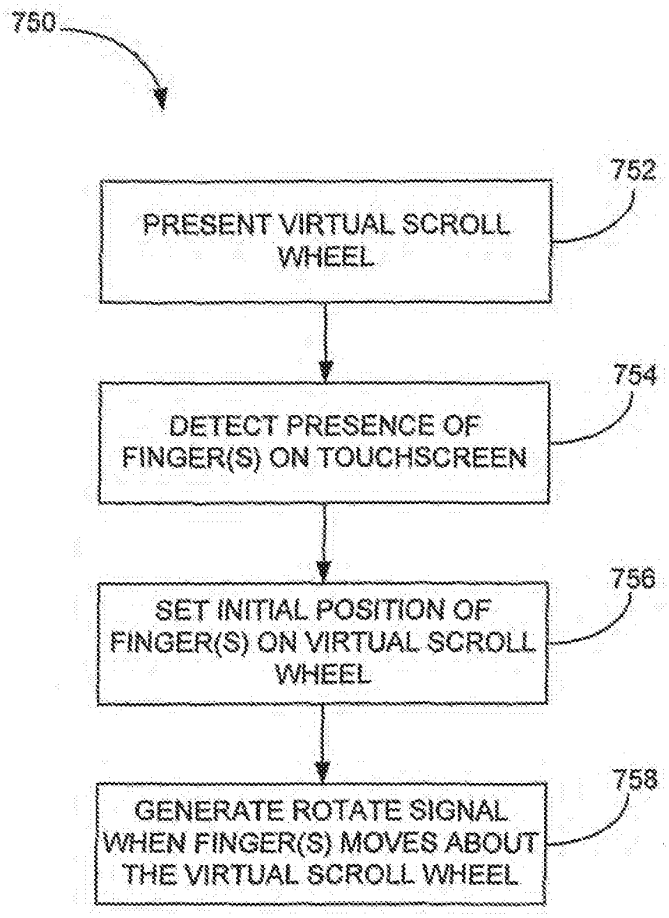

750
752
PRESENT VIRTUAL SCROLL WHEEL
754
DETECT PRESENCE OF FINGER(S) ON TOUCHSCREEN
756
SET INITIAL POSITION OF FINGER(S) ON VIRTUAL SCROLL WHEEL
758
GENERATE ROTATE SIGNAL WHEN FINGER(S) MOVES ABOUT THE VIRTUAL SCROLL WHEEL

FIG. 26

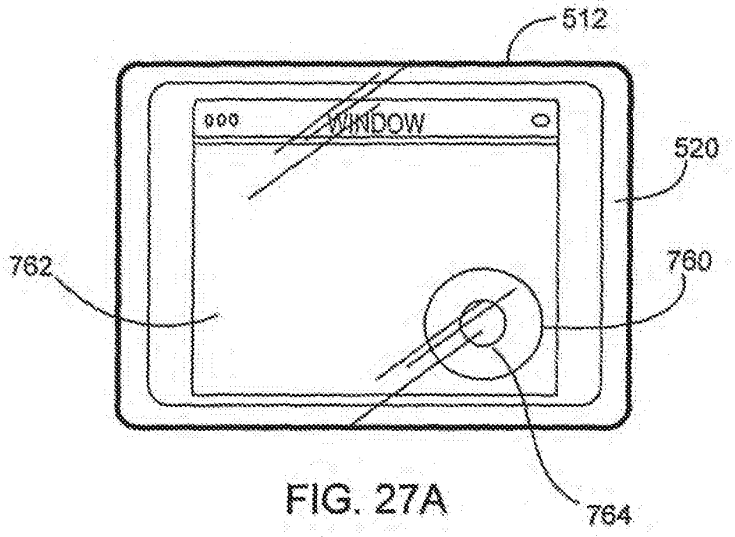


FIG. 27A

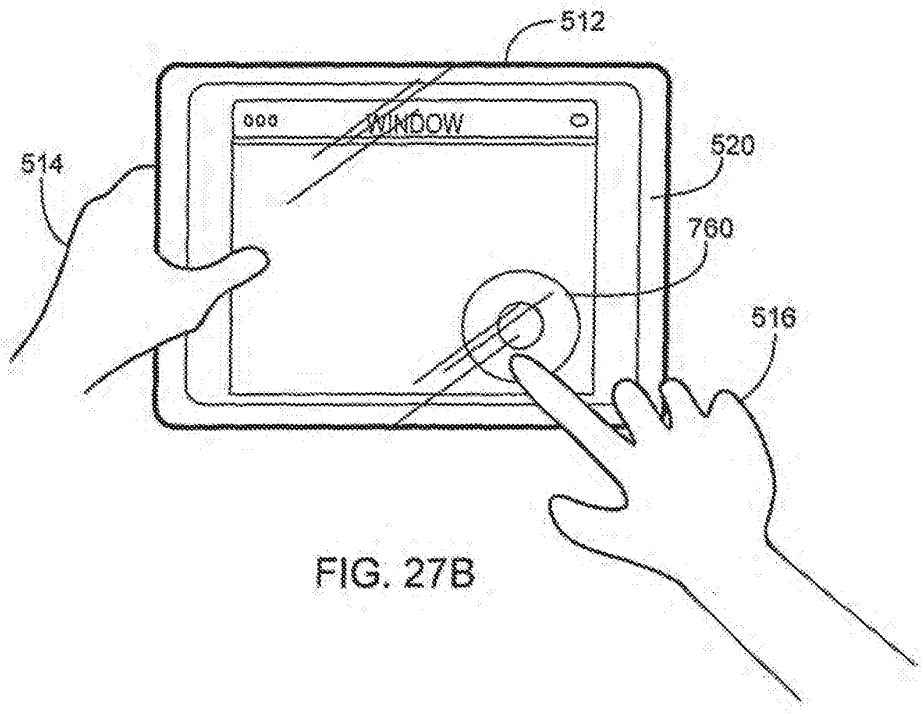


FIG. 27B

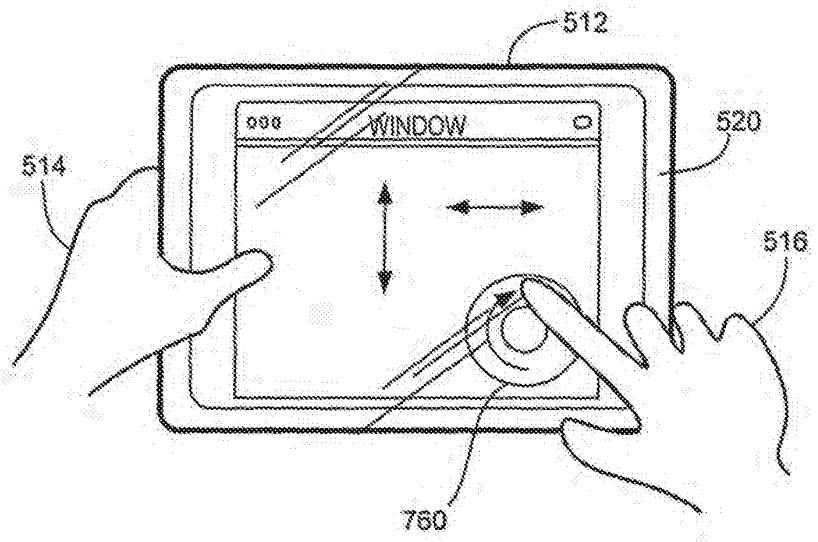


FIG. 27C

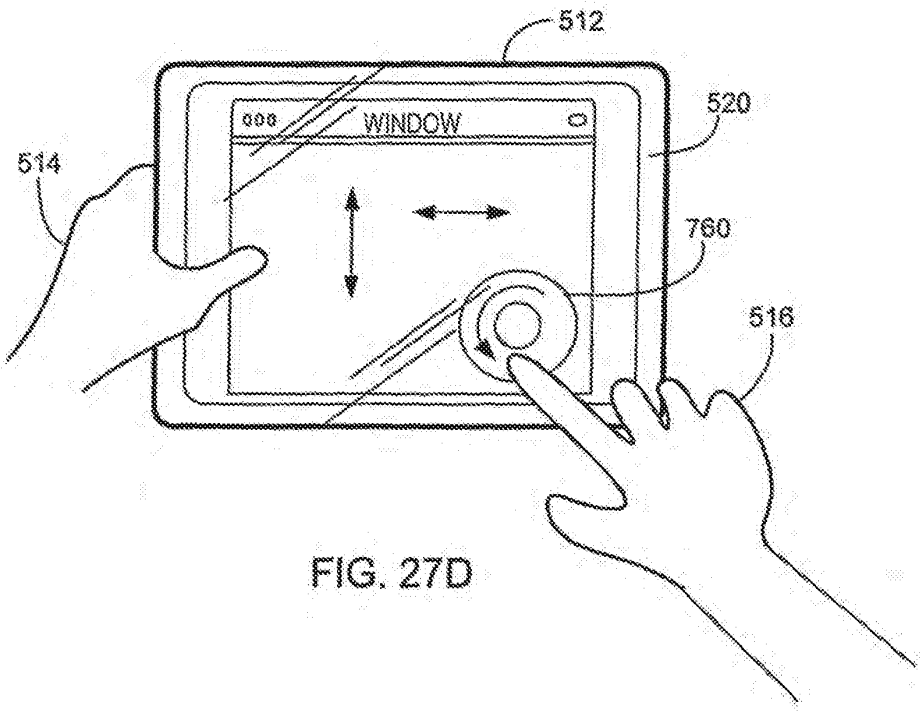


FIG. 27D

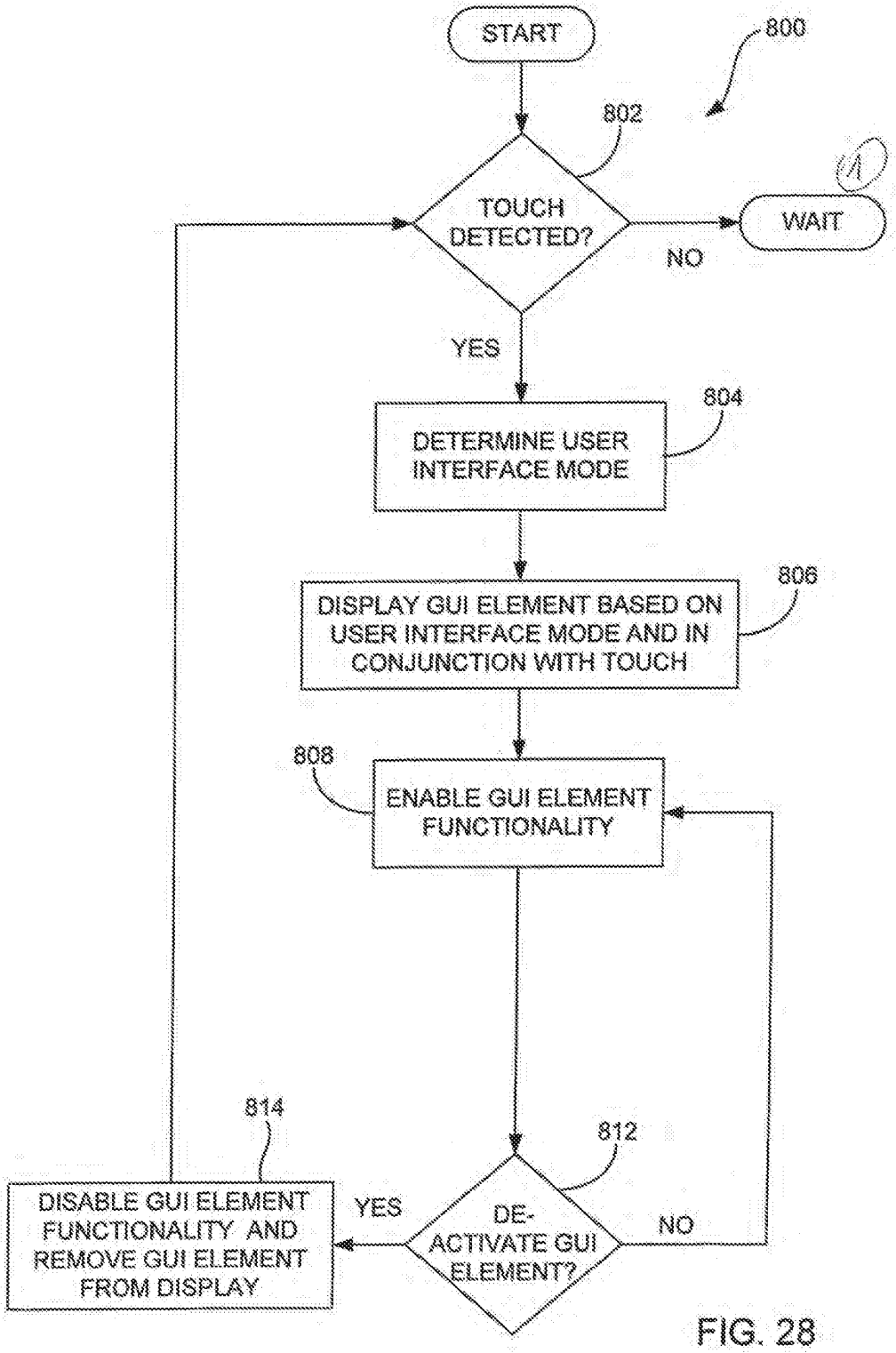

START
800
802
TOUCH DETECTED?
WAIT
NO
YES
804
DETERMINE USER INTERFACE MODE
806
DISPLAY GUI ELEMENT BASED ON USER INTERFACE MODE AND IN CONJUNCTION WITH TOUCH
808
ENABLE GUI ELEMENT FUNCTIONALITY
812
DE-ACTIVATE GUI ELEMENT?
YES
NO
814
DISABLE GUI ELEMENT FUNCTIONALITY AND REMOVE GUI ELEMENT FROM DISPLAY

FIG. 28

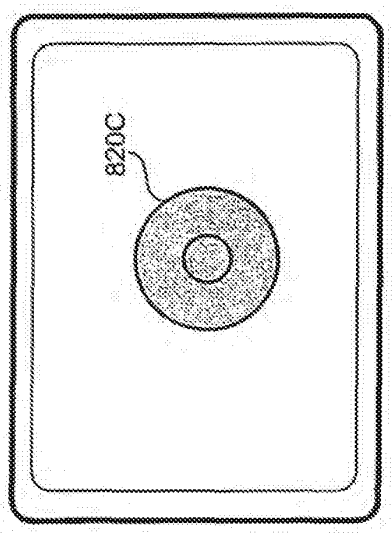


FIG. 29C

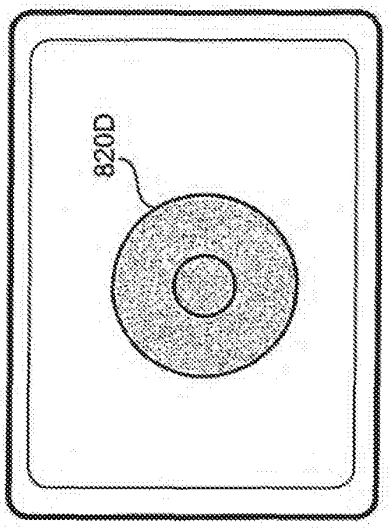


FIG. 29D

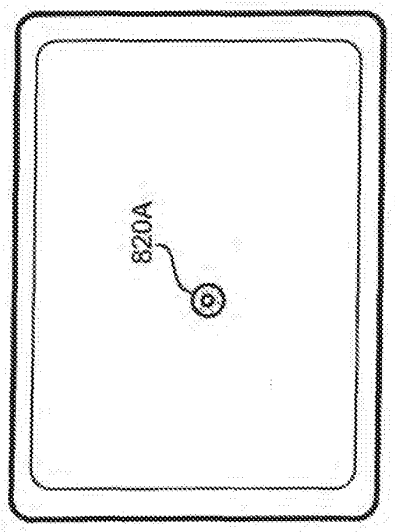


FIG. 29A

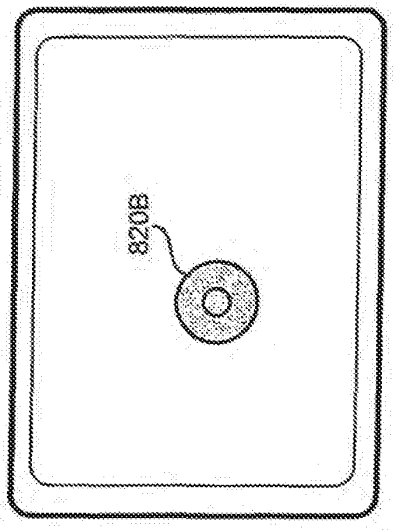


FIG. 29B

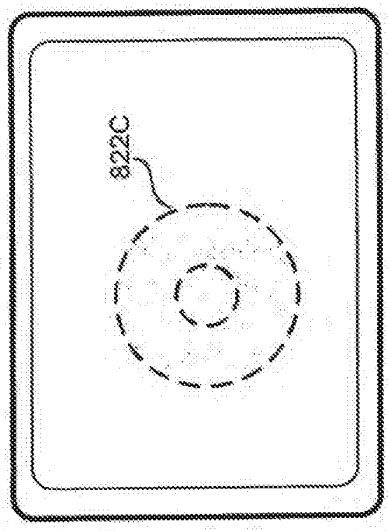


FIG. 30C

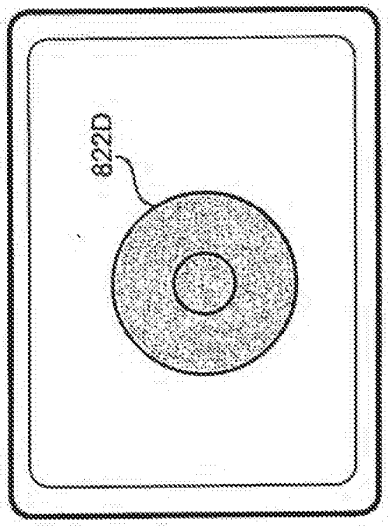


FIG. 30D

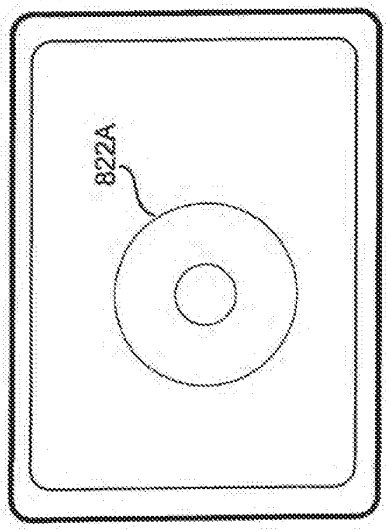


FIG. 30A

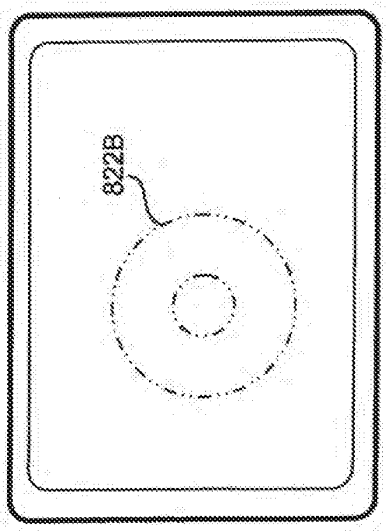


FIG. 30B

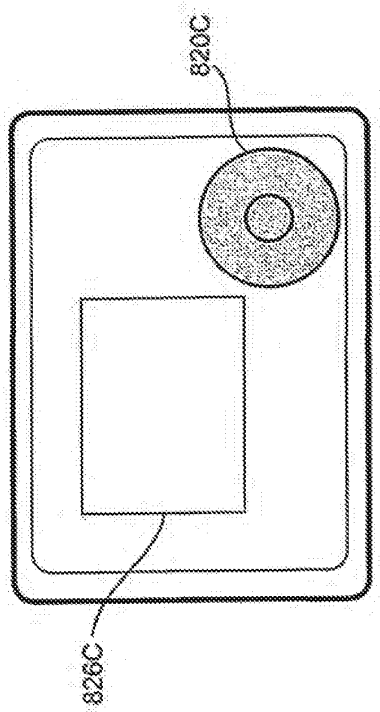


FIG. 31C

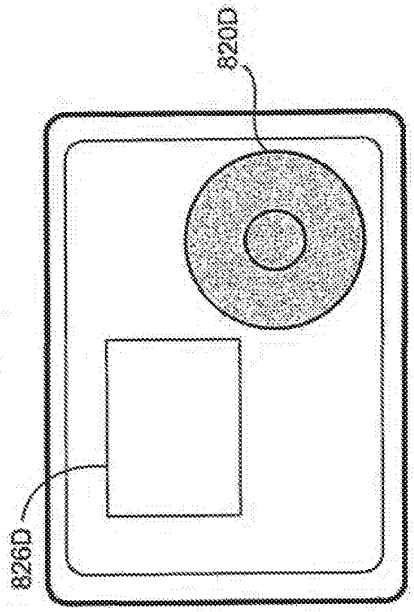


FIG. 31D

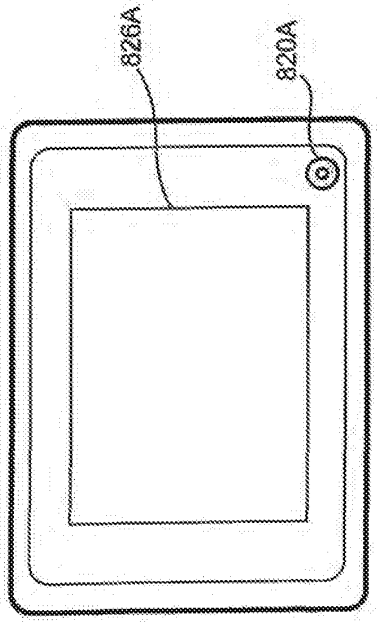


FIG. 31A

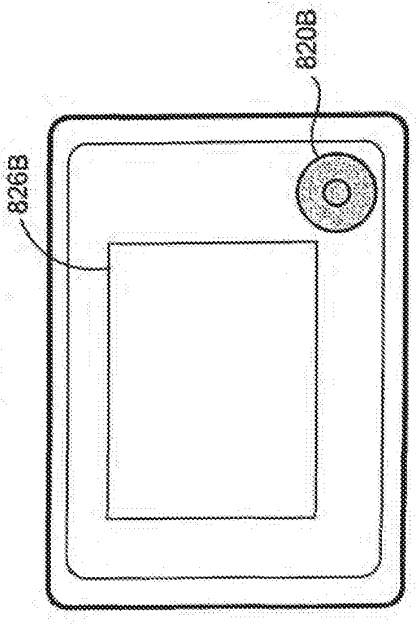


FIG. 31B

EX1002 - Page 997

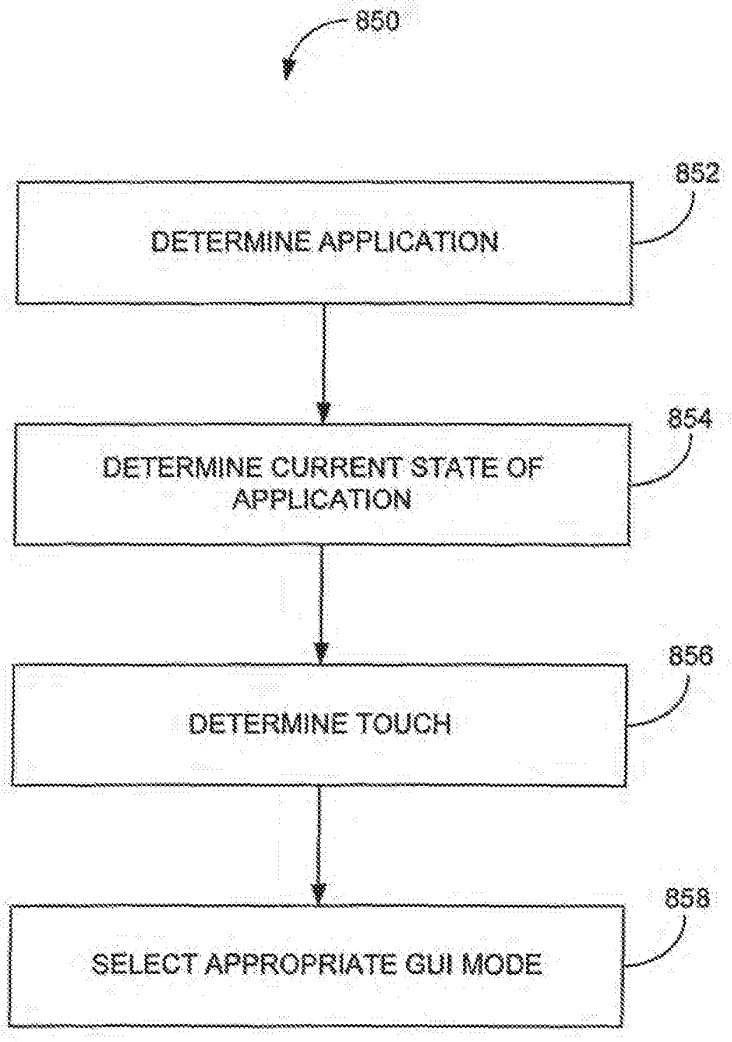

850
852
DETERMINE APPLICATION
854
DETERMINE CURRENT STATE OF APPLICATION
856
DETERMINE TOUCH
858
SELECT APPROPRIATE GUI MODE

FIG. 32

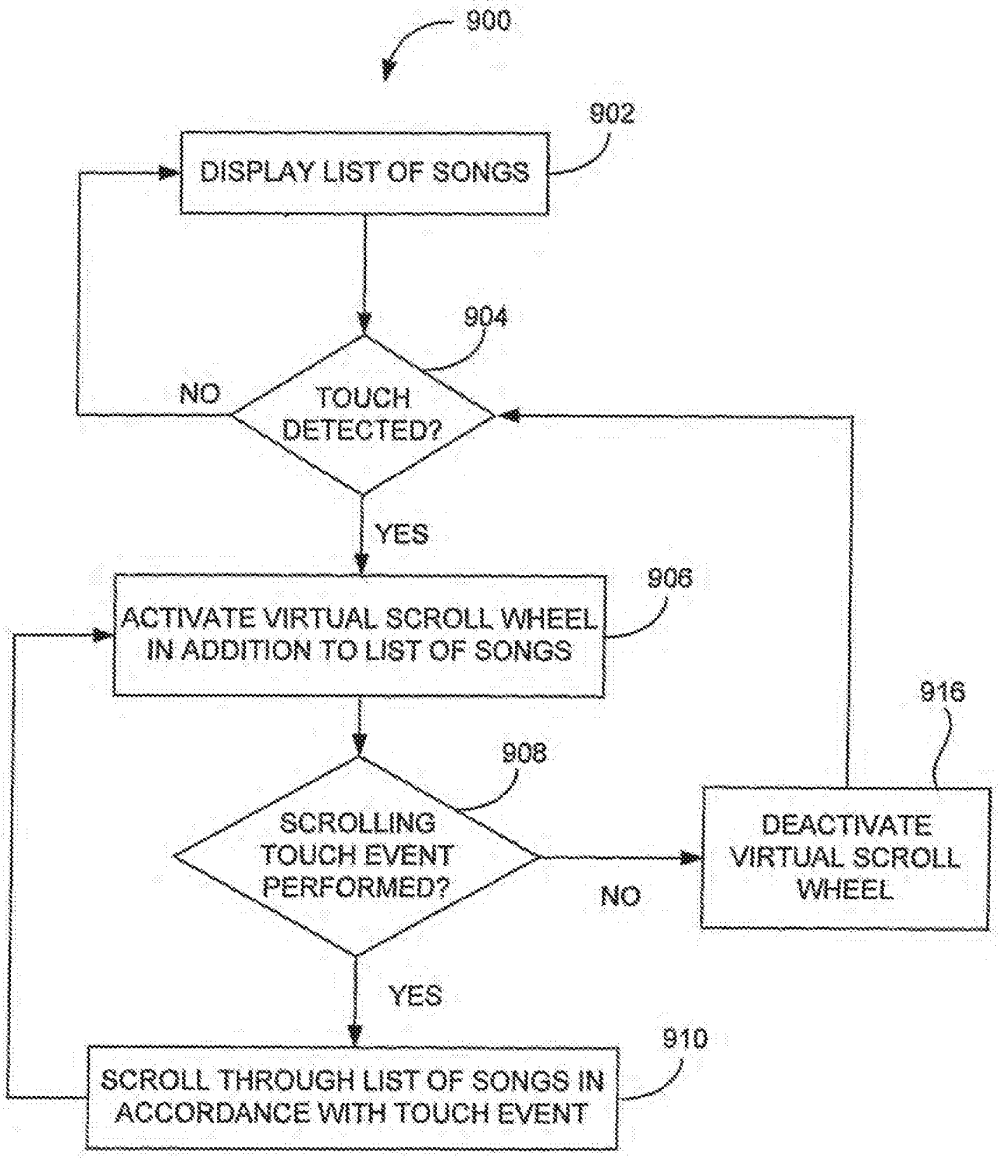

900
902
DISPLAY LIST OF SONGS
904
NO
TOUCH DETECTED?
YES
906
ACTIVATE VIRTUAL SCROLL WHEEL IN ADDITION TO LIST OF SONGS
908
SCROLLING TOUCH EVENT PERFORMED?
NO
916
DEACTIVATE VIRTUAL SCROLL WHEEL
YES
910
SCROLL THROUGH LIST OF SONGS IN ACCORDANCE WITH TOUCH EVENT

FIG. 33

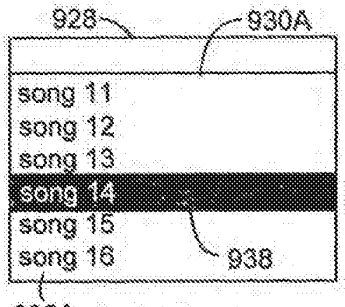


FIG. 34A

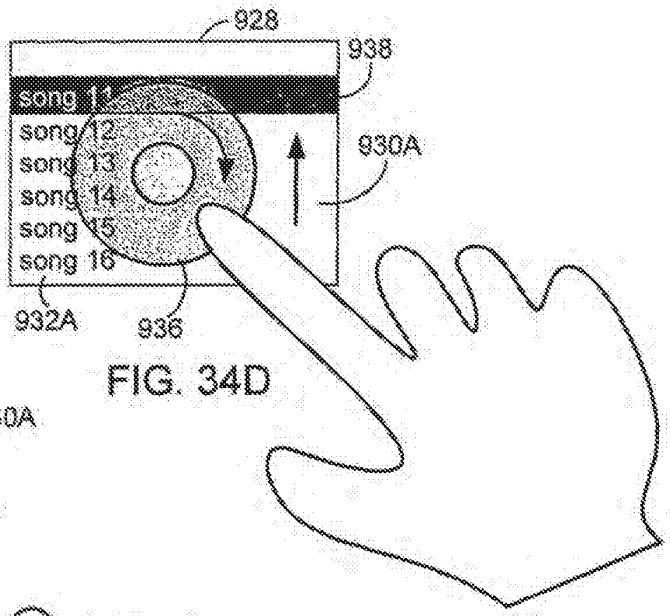


FIG. 34D

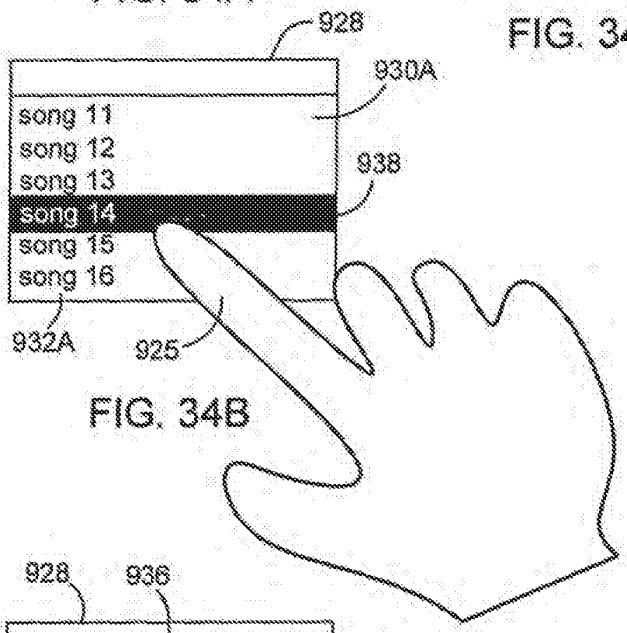


FIG. 34B

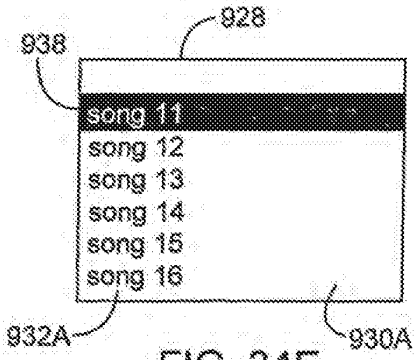


FIG. 34E

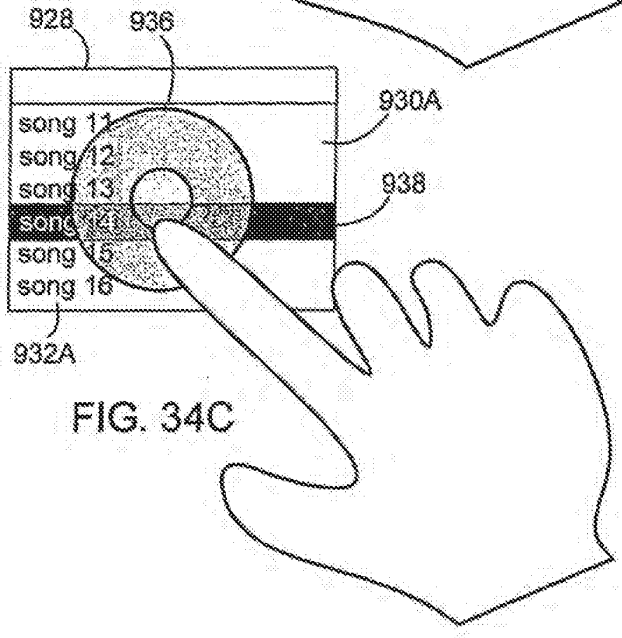


FIG. 34C

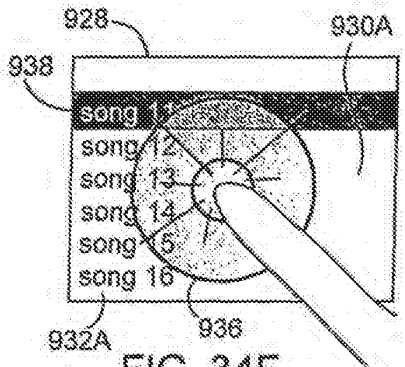


FIG. 34F

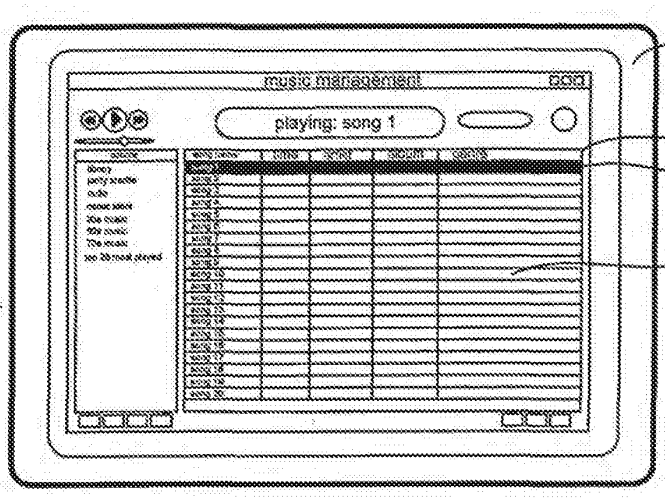


FIG. 35A

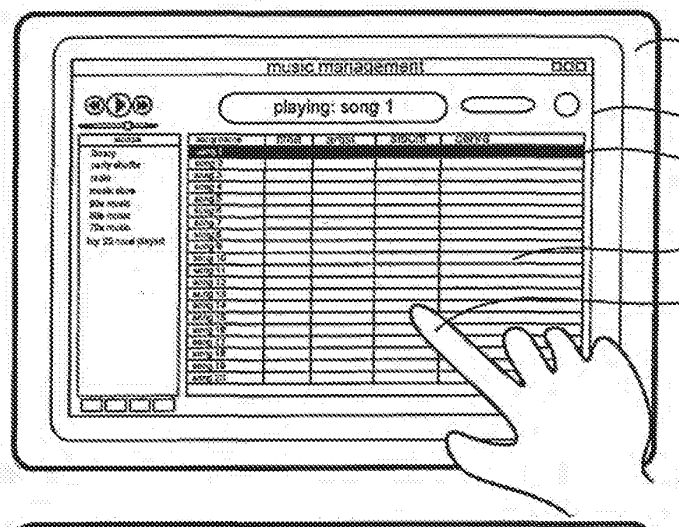


FIG. 35B

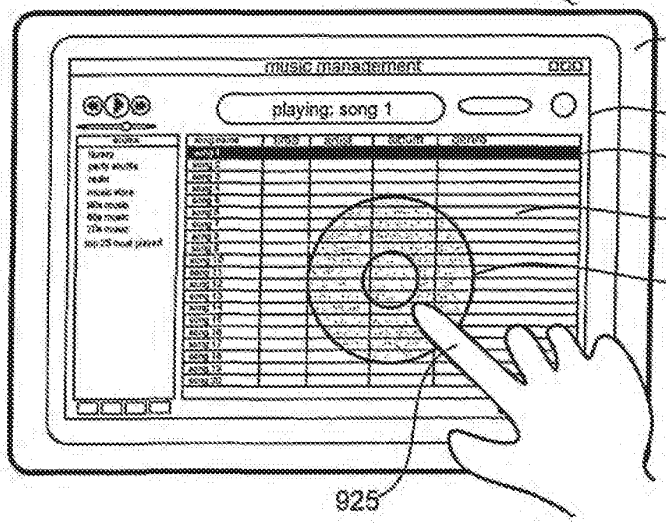


FIG. 35C

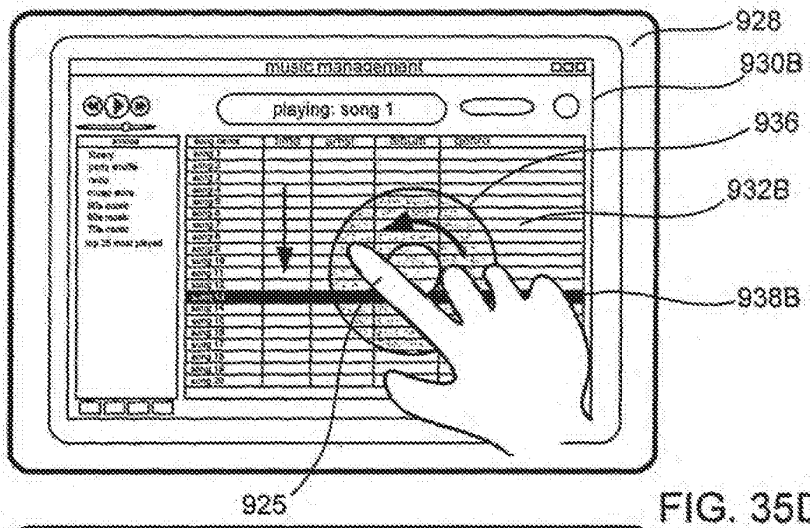


FIG. 35D

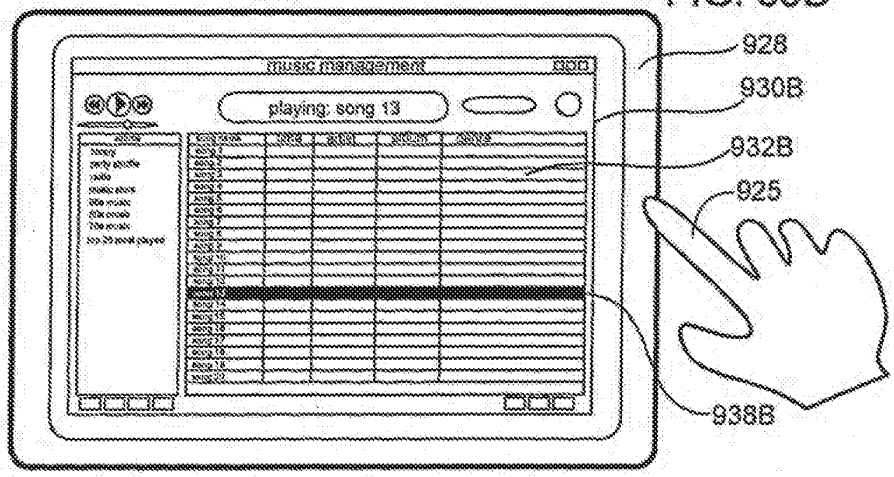


FIG. 35E

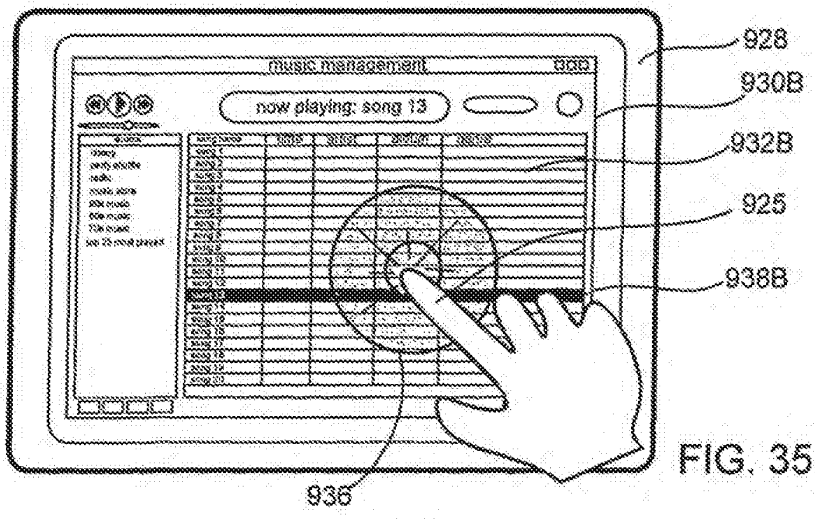


FIG. 35F

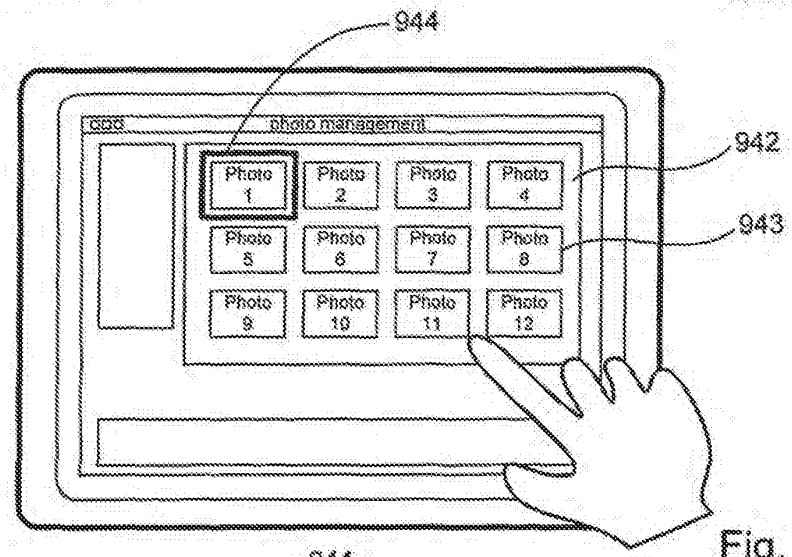


Fig. 36A

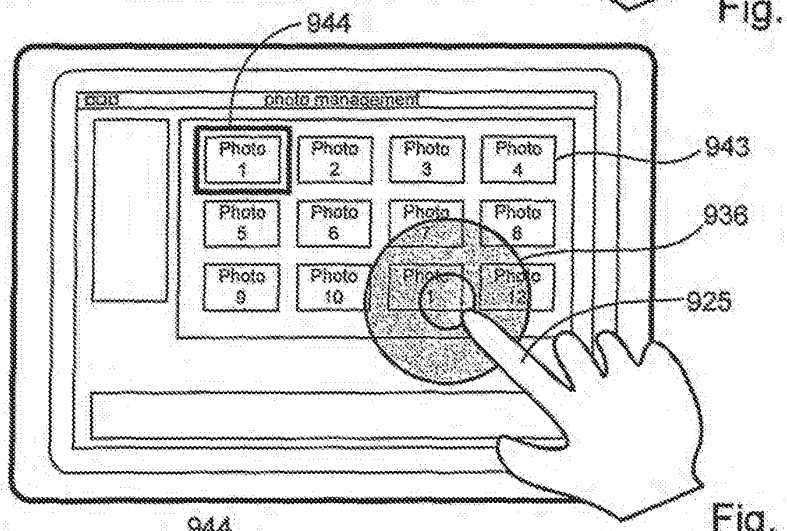


Fig. 36B

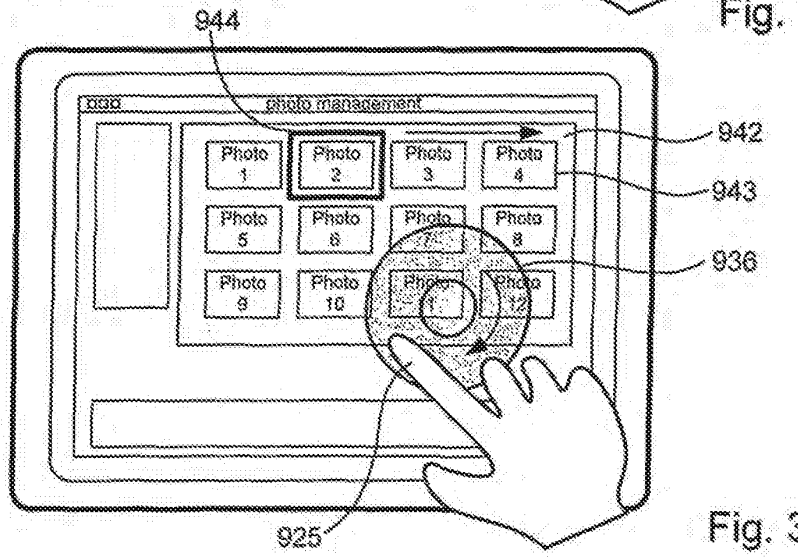


Fig. 36C

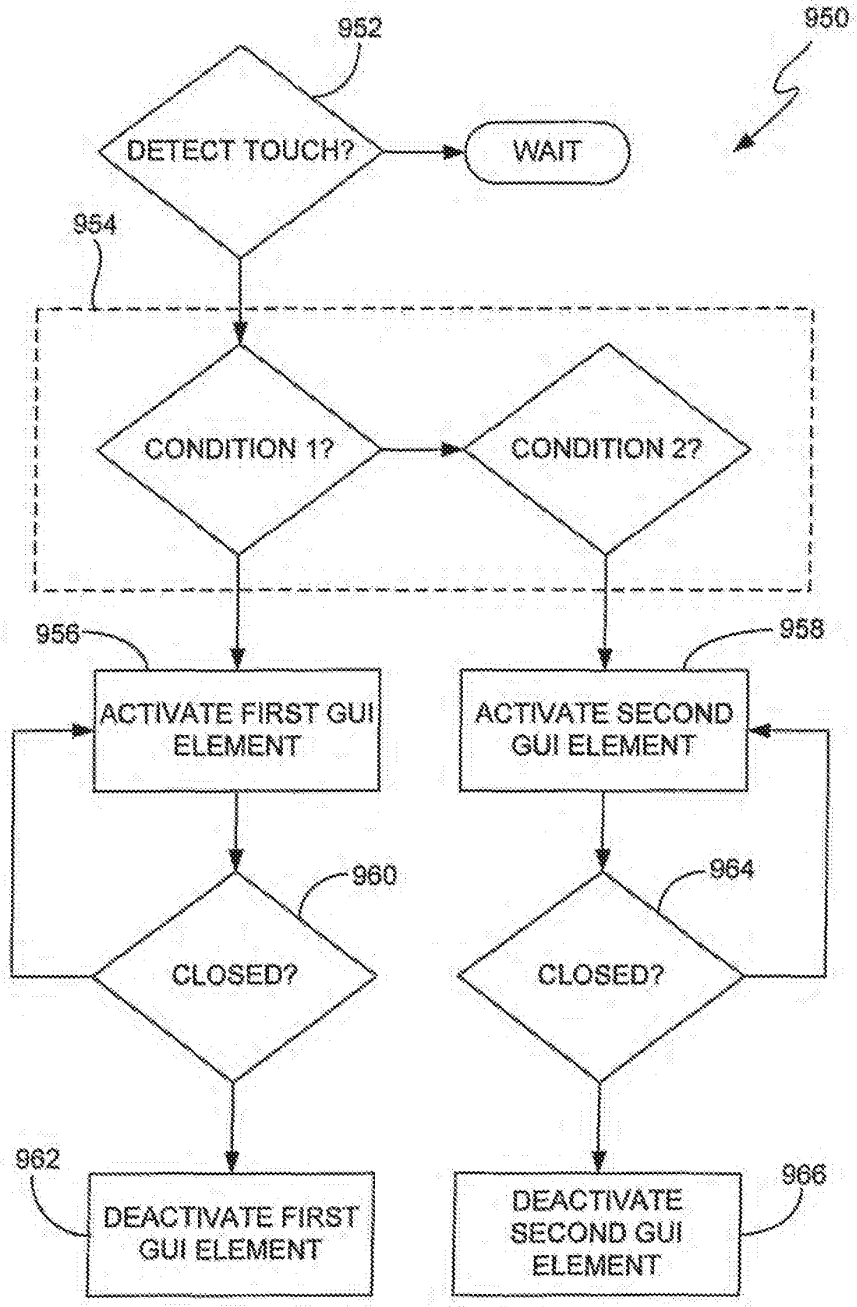

950
952
DETECT TOUCH?
WAIT
954
CONDITION 1?
CONDITION 2?
956
ACTIVATE FIRST GUI ELEMENT
958
ACTIVATE SECOND GUI ELEMENT
960
CLOSED?
964
CLOSED?
962
DEACTIVATE FIRST GUI ELEMENT
966
DEACTIVATE SECOND GUI ELEMENT

FIG. 37

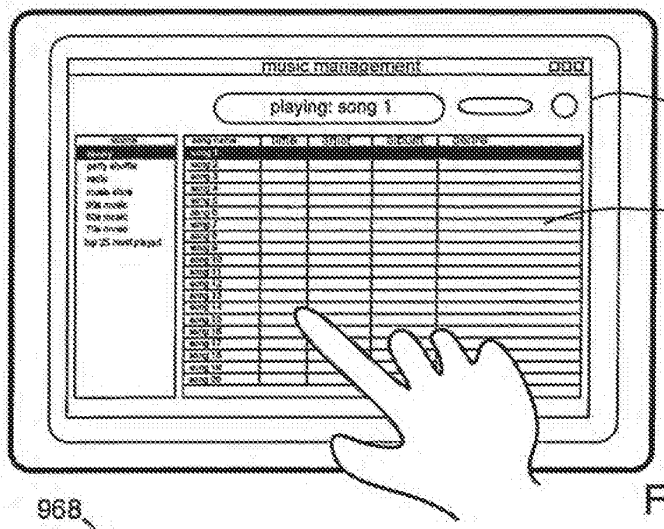


FIG. 38A

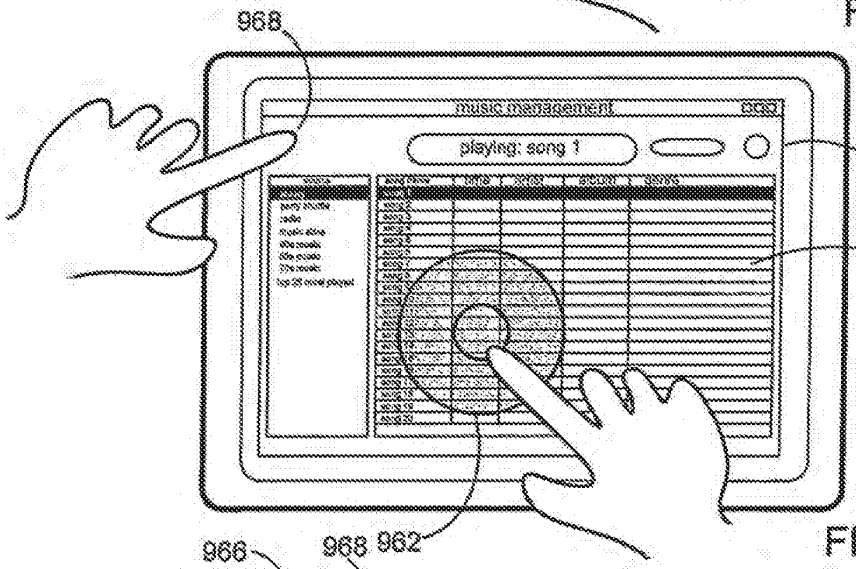


FIG. 38B

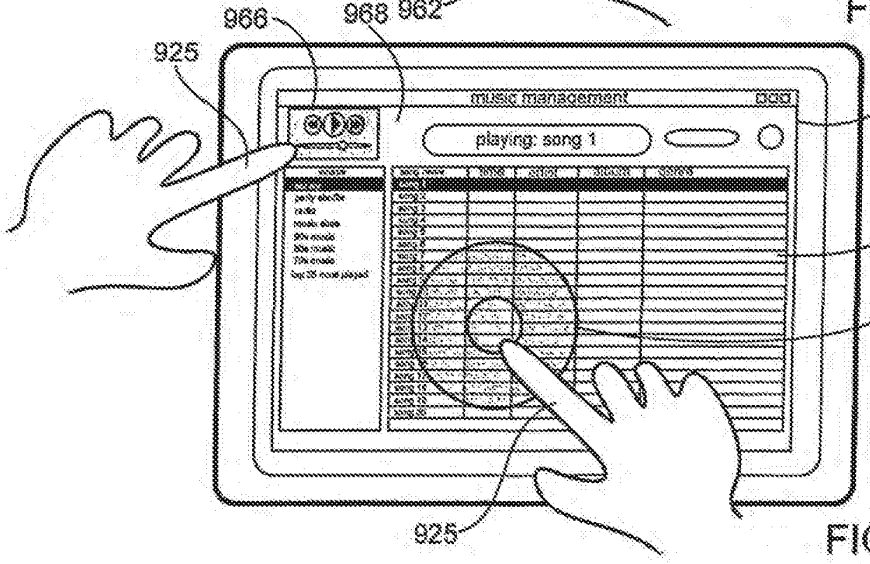


FIG. 38C

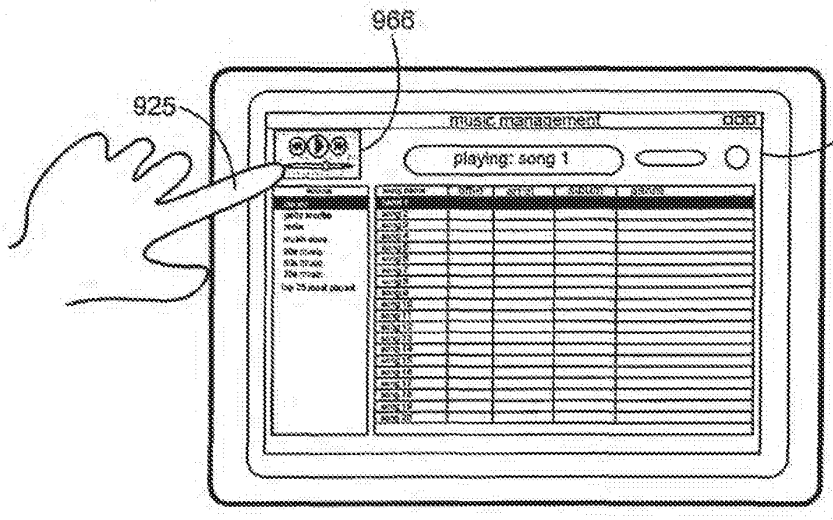


FIG. 38D

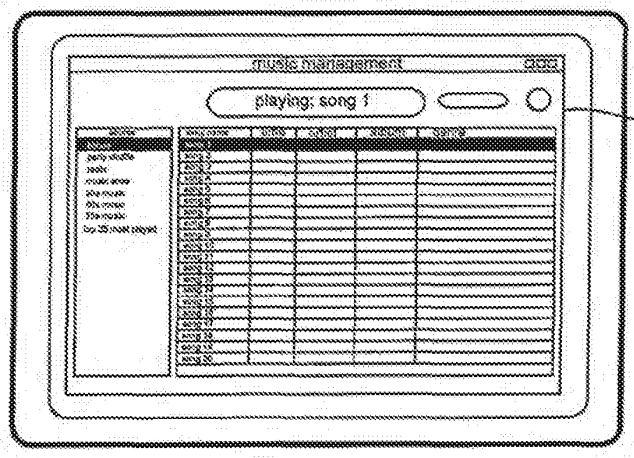


FIG. 38E

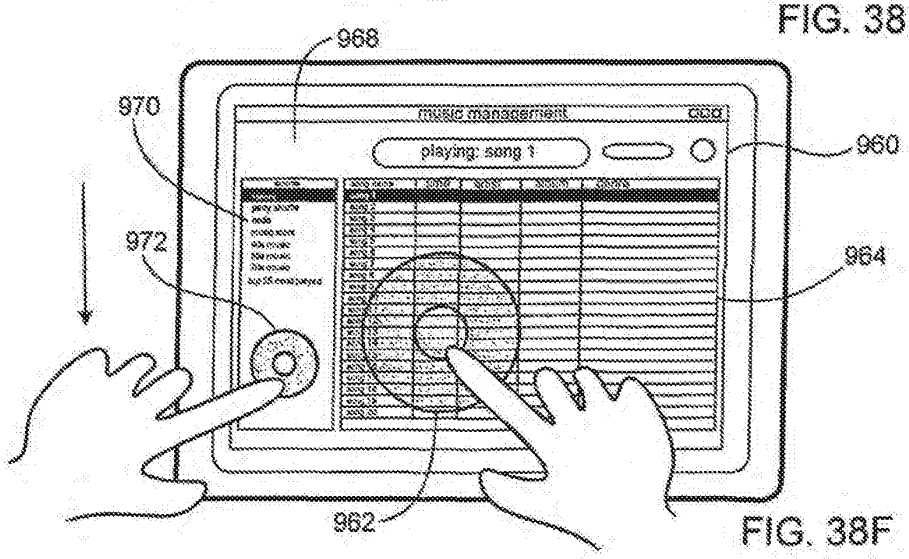


FIG. 38F

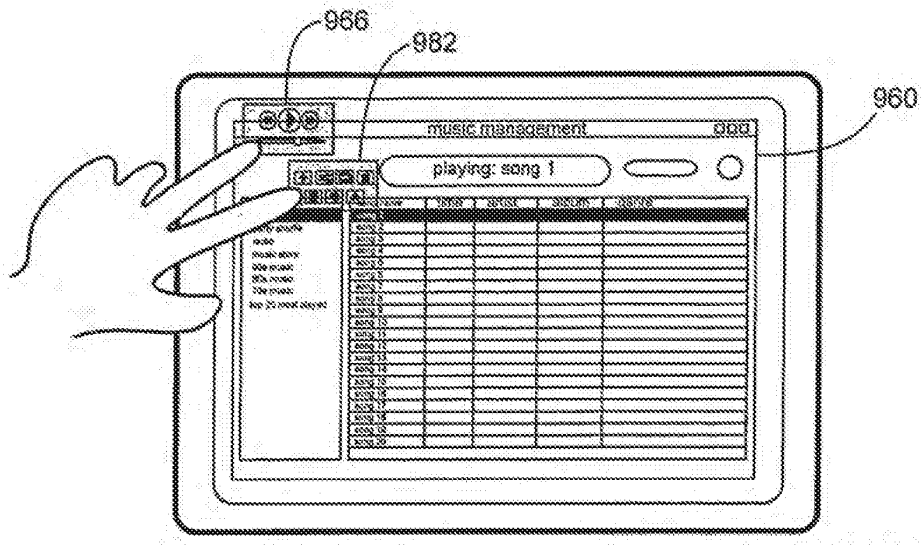


FIG. 38G

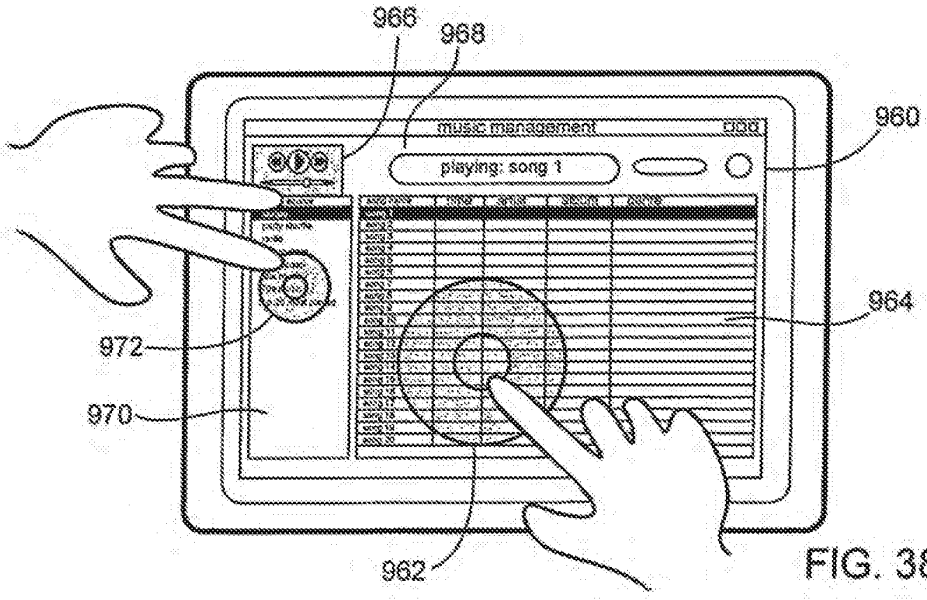


FIG. 38H

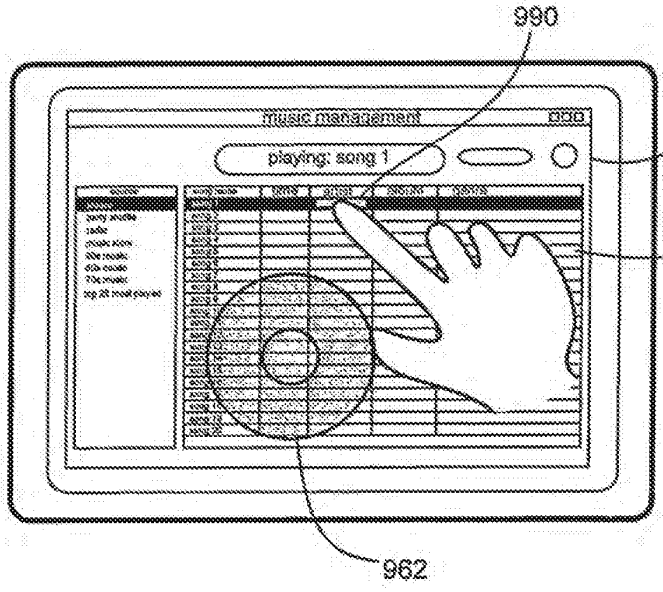


FIG. 38I

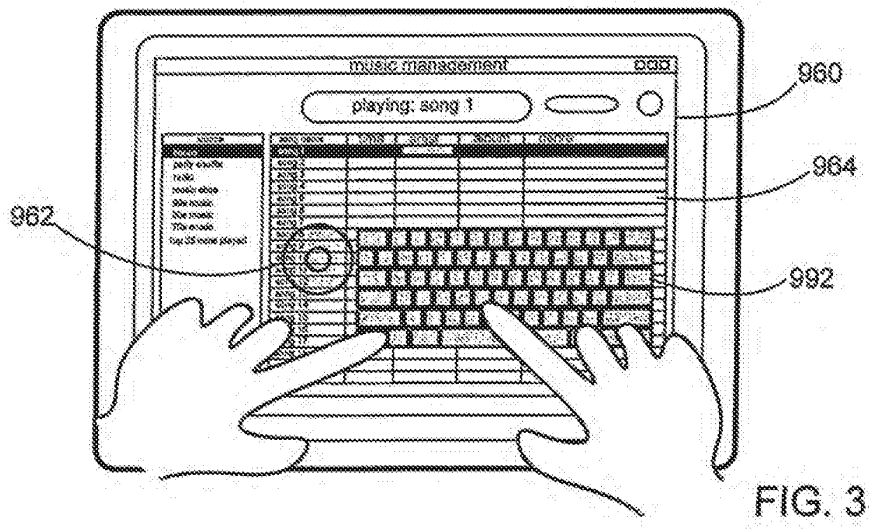


FIG. 38J

Electronic Acknowledgement Receipt

EFS ID:	25559465
Application Number:	11965046
International Application Number:	
Confirmation Number:	2809
Title of Invention:	Virtual Detents Through Vibrotactile Feedback
First Named Inventor/Applicant Name:	Michael D. Levin
Customer Number:	34300
Filer:	Michael T. Morlock/Amber Johnson
Filer Authorized By:	Michael T. Morlock
Attorney Docket Number:	IMM253
Receipt Date:	21-APR-2016
Filing Date:	27-DEC-2007
Time Stamp:	14:53:35
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	Transmittal.pdf	68346 db113311ab7b8670b5b8f9ed167b314e67d94883	no	1

Warnings:	
Information:	

2	Transmittal Letter	Certification.pdf	103345 36e80535d7ee0688e27abdc81cf31fc851977fe7	no	5
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	08a.pdf	110829 6f776c883e640c7d9daffdc97520666f45d44728	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
4	Non Patent Literature	JPOA.pdf	86917 8aea7a054f46e0574395dd4e68d6e5d3d1a69448	no	4
Warnings:					
Information:					
5	Foreign Reference	JP2003153354.pdf	1003187 000fb71b6aead90aa2f879944ccd64bac6fcbd9d	no	11
Warnings:					
Information:					
6	Foreign Reference	JP2006163206.pdf	1218046 9bab2a7c2a65ebae6b3fc73dbf986e69042722c6	no	28
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
7	Foreign Reference	WO2006020304A2.pdf	5896472 15840a0e7fa26c361bb37093c766018d9289680a	no	106
Warnings:					
Information:					
			Total Files Size (in bytes):	8487142	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	Conf No.: 2809
Michael D. Levin	)	
	)	Art Unit: 2623
Serial No. 11/965,046	)	
	)	Examiner: **Zubajlo, Jennifer L.**
Filed: December 27, 2007	)	
	)	

For: VIRTUAL DETENTS THROUGH VIBROTACTILE FEEDBACK

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Sir:

Transmitted herewith are the following documents for filing in the above-identified application:

1. Supplemental Information Disclosure Statement;
2. Form PTO/SB/08a listing Four(4) Documents;
3. Three (3) Foreign Patent Documents; and
4. One (1) Non-Patent Literature Document.

The Commissioner is hereby authorized to charge any deficiency to Deposit Account Number 20-1430.

Respectfully submitted,

Date: 4/21/2016

/Michael Morlock/
Michael T. Morlock
Reg. No. 62,245

KILPATRICK TOWNSEND & STOCKTON LLP
1001 West Fourth Street
Winston-Salem, NC 27101-2400
(336) 607-7300

Certificate of Electronic Filing
I hereby certify that this correspondence is being electronically filed with The United States Patent Office via EFS-Web on April 21, 2016.

/Amber C Johnson/
Amber C. Johnson

US2000 13534524 1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Michael D. Levin	)	
	)	Conf. No.: 2809
Serial No. 11/965,046	)	
	)	Art Unit: 2623
Filed: December 27, 2007	)	
	)	Examiner: Zubajlo, Jennifer L.
For: **VIRTUAL DETENTS THROUGH VIBROTACTILE FEEDBACK**	)	
Attorney Ref. IMM253 (051851-0339922)	)	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. §§ 1.97 and 1.98, applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I.. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the PTO/SB/08 forms attached hereto.

II. COPIES (check at least one box)

a. ☐ This application was filed before June 30, 2003. Accordingly, submitted herewith is a legible copy of (i) each U.S. and foreign patent; (ii) each publication or that portion which caused it to be listed; and (iii) all other information or that portion which caused it to be listed.

b. ☒ This application was filed on or after June 30, 2003. Accordingly, copies of cited U.S. patents and patent application publications therefore are not included. Copies of foreign patent documents and non-patent literature are included.

c. ☐ Some or all of the documents listed on the PTO/SB/08 forms are not enclosed because they were cited in the International Search Report and copies should already be in the PTO file. If copies are needed, please contact the undersigned.

III. CONCISE EXPLANATION OF THE RELEVANCE
(check at least one box)

a. ☒ **DOCUMENTS IN THE ENGLISH LANGUAGE**
The patents, publications, or other information listed on the attached PTO/SB/08 forms are in the English language and therefore, do not require a statement of relevancy.

b. ☒ **DOCUMENTS NOT IN THE ENGLISH LANGUAGE**
A concise explanation of the relevance of all patents, publications, or other information listed that is not in the English language is as follows:

JP 2003-153354 has an English Language Abstract.
JP 2006-163206 has an English language Abstract.

c. ☐ **ENGLISH LANGUAGE SEARCH REPORT**
An English language version of the search report or action that indicates the degree of relevance found by the foreign office is attached, thereby satisfying the requirement for a concise explanation. See MPEP 609(III)(A)(3).

d. ☐ **OTHER**
The following additional information is provided for the Examiner's consideration.

FEES

IV. ☒ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(b):
(check one box)

a. ☐ within three months of the filing date of a national application (37 C.F.R. § 1.97(b)(1)). No fee or statement is required. *(This section is not to be used with RCE's.)*

b. ☐ within three months of the date of entry of the national stage as set forth in § 1.491 in an international application (37 C.F.R. § 1.97(b)(2)). No fee or statement is required.

c. ☐ before the mailing of a first Office action after the filing of or concurrently with a Request for Continued Examination under § 1.114 (37 C.F.R. § 1.97(b)(4)). No fee or statement is required.

d. ☒ before the mailing date of a first Action on the merits (37 C.F.R. § 1.97(b)(3)). No fee or statement is required.

In the event that a first Office Action on the merits has been issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) below, or, if no statement has been made, charge our deposit account in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

V. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(c):
(check one box)

before the mailing date of a Final Office Action under 37 C.F.R. § 1.113 (See 37 C.F.R. § 1.97(c)(1)) or before the mailing date of a Notice of Allowance under 37 C.F.R. § 1.311 (See 37 C.F.R. § 1.97(c)(2)).

a. ☐ No statement; therefore, a fee in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

b. ☐ See the statement below. No fee is required.

VI. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(d)
after the period specified in 37 C.F.R. 1.97(c) but before payment of the issue fee; see statement and payment of fees below.

VII. STATEMENT UNDER 37 C.F.R. § 1.97(e) (check only one box)
The undersigned hereby states that

a. ☐ each item of information contained in the IDS was first cited in any communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS;

b. ☐ no item of information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS.

c. ☐ Some of the items of information were cited in a communication from a foreign Patent Office. As to this information, the undersigned states that each item of information contained in the IDS was first cited in a communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS. As to the remaining information, the undersigned hereby states that no item of this remaining information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application and, to the best of my knowledge after making reasonable inquiry, was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

VIII. ☐ PATENT TERM ADJUSTMENT

Each item of information contained in this Information Disclosure Statement was first cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of this Information Disclosure Statement. 37 C.F.R. § 1.704(d).

IX. PAYMENT OF FEES (check one box)

☐ Payment by credit card Form PTO-2038 in the amount of $180 required by 37 C.F.R. § 1.17(p) is enclosed for the above-identified fee.

☐ Please charge Deposit Account No. 20-1430 in the amount required by 37 C.F.R. § 1.17(p) for the above-indicated fee. A triplicate copy of this paper is attached.

☒ No fee is required.

If the Examiner has any questions concerning this IDS, he/she is requested to contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the PTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 20-1430.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 20-1430 for any additional fees required under 37 C.F.R. § 1.16 or under § 1.17.

Respectfully submitted,

Date: 4/21/2016

By: /Michael Morlock/
Michael T. Morlock (Reg. No. 62,245)

Attachment(s):
☒ PTO/SB/08
☒ Documents
☐ Fee
☐ Other

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

34300 7590 04/29/2016

Kilpatrick Townsend and Stockton, LLP
1001 W Fourth Street
Winston-Salem, NC 27101

EXAMINER	
ZUBAJLO, JENNIFER L	
ART UNIT	PAPER NUMBER
2623	

DATE MAILED: 04/29/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/965,046	12/27/2007	Michael D. Levin	IMM253	2809

TITLE OF INVENTION: Virtual Detents Through Vibrotactile Feedback

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	07/29/2016

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

34300 7590 04/29/2016
Kilpatrick Townsend and Stockton, LLP
1001 W Fourth Street
Winston-Salem, NC 27101

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/965,046	12/27/2007	Michael D. Levin	IMM253	2809

TITLE OF INVENTION: Virtual Detents Through Vibrotactile Feedback

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	07/29/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZUBAJLO, JENNIFER L	2623	345-156000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29
  NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27
  NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status.
  NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/965,046	12/27/2007	Michael D. Levin	IMM253	2809

34300 7590 04/29/2016

Kilpatrick Townsend and Stockton, LLP
1001 W Fourth Street
Winston-Salem, NC 27101

EXAMINER	
ZUBAJLO, JENNIFER L	
ART UNIT	PAPER NUMBER
2623	

DATE MAILED: 04/29/2016

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 11/965,046	Applicant(s) LEVIN, MICHAEL D.	
	Examiner JENNIFER ZUBAJLO	Art Unit 2623	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *Patent Board Decision 2/1/16*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-7 and 9-20*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 8/30/13 and 2/11/16
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/JENNIFER ZUBAJLO/ Examiner, Art Unit 2623 4/15/16	/Amare Mengistu/ Supervisory Patent Examiner, Art Unit 2623

Notice of References Cited	Application/Control No. 11/965,046	Applicant(s)/Patent Under Reexamination LEVIN, MICHAEL D.	
	Examiner JENNIFER ZUBAJLO	Art Unit 2623	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2004/0178989 A1	09-2004	Shahoian, Erik J.	G06F3/016	345/156
*	B	US-2006/0119573 A1	06-2006	Grant; Danny A.	G06F3/016	345/156
*	C	US-2004/0204811 A1	10-2004	Huang, Xiaodong	G06F3/016	701/50
*	D	US-2007/0222765 A1	09-2007	Nyyssonen; Tuomo	G06F1/1607	345/173
*	E	US-2006/0187216 A1	08-2006	Trent; Raymond A. JR.	G06F3/03547	345/173
*	F	US-7,720,552 B1	05-2010	Lloyd; Robert F.	G05B19/106	345/156
*	G	US-6,917,867 B2	07-2005	Huang; Xiaodong	G06F3/016	345/156
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	11/965,046
Filing Date	December 27, 2007
First Named Inventor	Michael D. Levin
Art Unit	2623
Examiner Name	Zubajlo, Jennifer L.
Attorney Docket Number	IMM253 (051851/0339922)

U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number - Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/J.Z./	1.	US 2004/0178989	09-16-2004	Shahoian	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] - Number[4] - Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/J.Z./	2.	JP 2003-084901	03-20-2003	Nissan Motor		
/J.Z./	3.	WO 02/073587	09-19-2002	Immersion Corp.		
/J.Z./	4.	JP 3085481	05-10-2002		Claims	
/J.Z./	5.	WO 03/036457	05-01-2003	Apple Computer Inc.		
/J.Z./	6.	WO 2006/94308	09-08-2006	Apple Computer Inc.		
/J.Z./	7.	JP 2005-267080	09-29-2005	Sony Corp.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
/J.Z./	8.	Japanese Patent Office, Notice of Reasons for Rejection, Application No. 2009-5440901 dated Feb. 4, 2014.	
/J.Z./	9.	Korean Patent Office, Notice of Preliminary Rejection, Application No. 10-2014-7010835 dated July 29, 2014.	
/J.Z./	10.	Korean Patent Office, Notice of Preliminary Rejection, Application No. 10-2009-7015696 dated January 23, 2014.	
/J.Z./	11.	Japanese Patent Office, Pretrial Report, Application No. 2009-544090 dated July 23, 2014.	
/J.Z./	12.	Japanese Patent Office, Notice of Reasons for Rejection, Application No. 2013-217205 dated September 30, 2014.	
/J.Z./	13.	Japanese Patent Office, Notice of Reasons for Rejection, Application No. 2009-544090 dated October 28, 2014.	
/J.Z./	14.	Japanese Patent Office, Decision of Rejection, Application No. 2013-217205 dated August 18, 2014.	

Examiner Signature	/Jennifer Zubajlo/	Date Considered	04/15/2016

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	11/965,046
Filing Date	December 27, 2007
First Named Inventor	Michael D. Levin
Art Unit	2623
Examiner Name	Zubajlo, Jennifer L.
Attorney Docket Number	IMM253 (051851/0339922)

U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number - Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] - Number[4] - Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/J.Z./	1.	JP 2003-153354	05-23-2003	Alps Electric Co. Ltd.		X
/J.Z./	2.	JP 2006-163206	06-22-2006	NTT Docomo Inc.		X
/J.Z./	3.	WO 2006/020304	02-23-2006	Apple Computer Inc.		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
/J.Z./	4.	Japanese Patent Office, Notice of Reasons for Rejection, Application No. JP 2015-087121 dated February 16, 2016.	

Examiner Signature	/Jennifer Zubajlo/	Date Considered	04/21/2016

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11965046	LEVIN, MICHAEL D.
	Examiner	**Art Unit**
	JENNIFER ZUBAJLO	2623

CPC							
Symbol						**Type**	**Version**
G06F		3	/	016		F	2013-01-01
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CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

/JENNIFER ZUBAJLO/ Examiner.Art Unit 2623	4/15/16	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/AMARE MENGISTU/ Supervisory Patent Examiner.Art Unit 2623	04/25/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11965046	LEVIN, MICHAEL D.
	Examiner	**Art Unit**
	JENNIFER ZUBAJLO	2623

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
345	156	G 0 9 G 5 / 00 (2006.0)	

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
345	173				

/JENNIFER ZUBAJLO/ Examiner.Art Unit 2623	4/15/16	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/AMARE MENGISTU/ Supervisory Patent Examiner.Art Unit 2623	04/25/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office

Part of Paper No. 20160210

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11965046	LEVIN, MICHAEL D.
	Examiner	**Art Unit**
	JENNIFER ZUBAJLO	2623

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	17	17												
2	2	18	18												
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12	12														
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14	14														
15	15														
16	16														

/JENNIFER ZUBAJLO/ Examiner.Art Unit 2623	4/15/16	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/AMARE MENGISTU/ Supervisory Patent Examiner.Art Unit 2623	04/25/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11965046	LEVIN, MICHAEL D.
	Examiner	Art Unit
	JENNIFER ZUBAJLO	2629

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/20/2010	03/15/2011	07/14/2011	02/25/2012	08/14/2012	04/15/2016			
1	1	✓	✓	✓	✓	✓	=			
2	2	✓	✓	✓	✓	✓	=			
3	3	✓	✓	✓	✓	✓	=			
4	4	✓	✓	✓	✓	✓	=			
5	5	✓	✓	✓	✓	✓	=			
6	6	✓	✓	✓	✓	✓	=			
7	7	✓	✓	✓	✓	✓	=			
	8	✓	✓	-	-	-	-			
9	9	✓	✓	✓	✓	✓	=			
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17	17	✓	✓	✓	✓	✓	=			
18	18	✓	✓	✓	✓	✓	=			
19	19	✓	✓	✓	✓	✓	=			
8	20			✓	✓	✓	=			

04/15/2016

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	11/956,046
Filing Date	December 27, 20007
First Named Inventor	Michael D. Levin
Art Unit	2629 2623
Examiner Name	Zubajlo, Jennifer L.
Attorney Docket Number	IMM253 (51851/339922)

U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number - Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] - Number[4] - Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/J.Z./	1.	JP 2003-295959	10-17-2003	Alps Electric Co. Ltd.		X
/J.Z./	2.	JP 2004-094570	03-25-2004	Matsushita Electric Ind. Co. Ltd.		X
/J.Z./	3.	JP 2006-251845	09-21-2006	Alps Electric Co. Ltd.		X
/J.Z./	4.	JP 2008-016426	01-24-2008	Tokai Rika Co. Ltd.		X

NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
/J.Z./	5.	Translation of Notice of Reasons for Rejection mailed June 18, 2013 for corresponding Japanese Application No. 2009-544090.	

Examiner Signature	/Jennifer Zubajlo/	Date Considered	04/15/2016

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11965046	LEVIN, MICHAEL D.
	Examiner	Art Unit
	JENNIFER ZUBAJLO	2623

CPC- SEARCHED		
Symbol	Date	Examiner
G06F3/016	4/15/2016	JZ

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
345	156-179	4/15/2016	JZ
all	all - word search	4/15/2016	JZ

SEARCH NOTES		
Search Notes	Date	Examiner
Updated EAST Search	4/15/2016	JZ

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	Searched all the above US class/subclass and CPC	4/15/2016	JZ

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

34300 7590 04/29/2016
Kilpatrick Townsend and Stockton, LLP
1001 W Fourth Street
Winston-Salem, NC 27101

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/965,046	12/27/2007	Michael D. Levin	IMM253	2809

TITLE OF INVENTION: Virtual Detents Through Vibrotactile Feedback

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	07/29/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZUBAJLO, JENNIFER L	2623	345-156000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ~~Kilpatrick Townsend & Stockton LLP~~
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Immersion Corporation

(B) RESIDENCE: (CITY and STATE OR COUNTRY): San Jose, CA

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☒ Payment by credit card. Form PTO-2038 is attached.
☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 20-1430 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Michael Morlock/ Date 7/21/2016
Typed or printed name Michael Morlock Registration No. 62,245

PTO/ 85 Part B (10-13) Approved for use through 10/31/2013 OMB 0651-0033 U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	11965046
Filing Date:	27-Dec-2007
Title of Invention:	Virtual Detents Through Vibrotactile Feedback
First Named Inventor/Applicant Name:	Michael D. Levin
Filer:	Michael T. Morlock/Laura Smith
Attorney Docket Number:	IMM253

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt	
EFS ID:	26412474
Application Number:	11965046
International Application Number:	
Confirmation Number:	2809
Title of Invention:	Virtual Detents Through Vibrotactile Feedback
First Named Inventor/Applicant Name:	Michael D. Levin
Customer Number:	34300
Filer:	Michael T. Morlock
Filer Authorized By:	
Attorney Docket Number:	IMM253
Receipt Date:	21-JUL-2016
Filing Date:	27-DEC-2007
Time Stamp:	11:43:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$960
RAM confirmation Number	072116INTEFSW11470700
Deposit Account	1003
Authorized User	Jennifer Jacobs
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	Transmittal.pdf	80183 b20dd89769b87a02fd5a5ca7cecfecd595dcafb9	no	1
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	PartB.pdf	171531 36f399be3ef74e9026b2a7bdc9ba1a68a19aa037	no	1
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30111 36df646b109de079f516f93fe56817cae1733c6a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	281825		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	Conf No.: 2809
Michael D. Levin	)	
	)	Art Unit: 2623
Serial No. 11/965,046	)	
	)	Examiner: **Zubajlo, Jennifer L.**
Filed: December 27, 2007	)	
	)	

For: VIRTUAL DETENTS THROUGH VIBROTACTILE FEEDBACK

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Commissioner:

Transmitted herewith are the following documents for filing in the above-identified application:

1. Transmittal;
2. Part B – Fee Transmittal; and
3. EFS-Web Payment in the amount of $960.00

The Commissioner is hereby authorized to charge any additional fees required by this action, or credit any overpayment, to Deposit Account Number 20-1430.

Respectfully submitted,

Date: 7/21/2016

/Michael Morlock/
Michael T. Morlock
Reg. No. 62,245

KILPATRICK TOWNSEND & STOCKTON LLP
1001 West Fourth Street
Winston-Salem, NC 27101-2400
(336) 607-7300

Certificate of Electronic Filing
I hereby certify that this correspondence is being electronically filed with the United States Patent Office via EFS-Web on July 21, 2016.

/Laura J. Smith/
Laura J. Smith

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/965,046	08/30/2016	9430042	IMM253	2809

34300 7590 08/10/2016

Kilpatrick Townsend and Stockton, LLP
1001 W Fourth Street
Winston-Salem, NC 27101

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 1796 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Michael D. Levin, Los Altos, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	11/965,046
Filing Date	December 27, 2007
First Named Inventor	Michael D. Levin
Art Unit	2623
Examiner Name	Zubajlo, Jennifer L.
Attorney Docket Number	IMM253 (051851/0339922)

U.S. PATENT DOCUMENTS

Examiner Initials *	Cite No.[1]	Document Number Number - Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3] - Number[4] - Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	1.	JP 2004-530200	09-30-2004	Unknown		X

NON PATENT LITERATURE DOCUMENTS

Examiner Initials *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	2.	Japanese Patent Office, Decision of Rejection, Application No. 2015-087121 dated August 8, 2016.	

Examiner Signature		Date Considered	

(19)日本国特許庁(JP)　(12)公表特許公報(A)　(11)特許出願公表番号
特表2004-530200
(P2004-530200A)
(43)公表日　平成16年9月30日(2004.9.30)

(51)Int.Cl.[7]	F I	テーマコード（参考）
G06F 3/033	G06F 3/033 310Y	5B087

審査請求 未請求　予備審査請求 有　（全 196 頁）

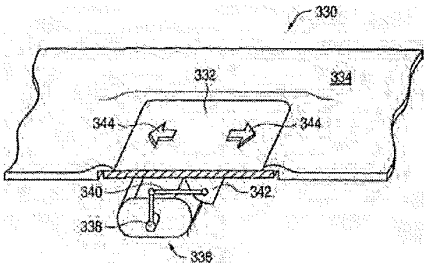
(21)出願番号	特願2002-572160 (P2002-572160)
(86)(22)出願日	平成14年3月8日 (2002.3.8)
(85)翻訳文提出日	平成15年9月9日 (2003.9.9)
(86)国際出願番号	PCT/US2002/007102
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(31)優先権主張番号	60/274,444
(32)優先日	平成13年3月9日 (2001.3.9)
(33)優先権主張国	米国 (US)
(31)優先権主張番号	09/917,263
(32)優先日	平成13年7月26日 (2001.7.26)
(33)優先権主張国	米国 (US)

(71)出願人　500390995
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弁理士　薬丸　誠一
(74)代理人　100114432
弁理士　中谷　寛昭

最終頁に続く

(54)【発明の名称】ラップトップコンピュータ及びその他の携帯用機器のための触感インターフェイス

(57)【要約】
【課題】コンピュータに入力を提供する触感フィードバックタッチ制御機器。
【解決手段】タッチ入力装置は、ユーザの接触位置に基づいて位置情報をコンピュータに与える平面状のタッチ面を備える。該コンピュータは、少なくとも前記位置情報に基づいて、表示されたグラフィック環境にカーソルを位置させるか、又は異なる機能を発揮させることができる。少なくとも一つのアクチュエータ（３３６）が、また前記タッチ入力装置に連結されており、ユーザに触感覚を与えるべく力を出力する。該アクチュエータ（３３６）は、タッチパッド（３３２）を横方向に移動させるか、又は別体の面が作動し得る。フラットＥコアアクチュエータ、圧電アクチュエータ、又はその他の種類のアクチュエータが力を与えるために利用できる。前記タッチ入力機器は異なるコンピュータの機能を制御するために複数の異なる領域を備え得る。
【選択図】図１３



【特許請求の範囲】
【請求項１】
コンピュータに信号を入力すると共に、ユーザに力を出力する触感フィードバックタッチ制御機器であって、
該制御機器は、前記ユーザが触れる場所を二次元で表す位置信号を与える略平面状のタッチ面を有するタッチ入力装置と、該タッチ入力装置に連結された少なくとも一つのアクチュエータとを備え、
前記コンピュータは、前記位置信号に由来する位置情報を受け取るものであり、前記アクチュエータは、前記タッチ面に触れるユーザに対して触感を与えるべく該タッチ入力装置を前記面に略平行に横方向に動かす力を前記タッチ入力装置に出力すると共に、前記コンピュータにより出力される力の情報に基づいて前記力を出力するものである触感フィードバックタッチ制御機器。
【請求項２】
前記コンピュータは、少なくとも前記位置信号にある程度基づいて、表示装置に表示されるグラフィック環境中にカーソルを位置させるものである請求項１に記載の触感フィードバックタッチ制御機器。
【請求項３】
前記タッチ入力装置は、タッチパッドであり、該タッチパッドは、前記コンピュータの表示スクリーンと別体化されている請求項１に記載の触感フィードバックタッチ制御機器。
【請求項４】
前記タッチ入力装置は、前記コンピュータのハウジングに一体化されている請求項１に記載の触感フィードバックタッチ制御機器。
【請求項５】
前記ユーザは、該ユーザの指で前記タッチ面に接触する請求項１に記載の触感フィードバックタッチ制御機器。
【請求項６】
前記ユーザは、該ユーザが保持する物体で前記タッチ面に接触する請求項１に記載の触感フィードバックタッチ制御機器。
【請求項７】
前記少なくとも一つのアクチュエータは、前記タッチ入力装置の面に略平行な第一の横方向に第一の力を出力する第一のアクチュエータであり、前記タッチ入力装置に連結されると共に、前記タッチ入力装置の面に、該面に略平行且つ前記第一の横方向に略垂直な第二の横方向に第二の力を出力する第二のアクチュエータを更に備えている請求項１に記載の触感フィードバックタッチ制御機器。
【請求項８】
前記アクチュエータは、直線方向の自由度に出力を与えるリニアアクチュエータであり、該アクチュエータは、前記タッチパッドと、下部のハウジングとの間に連結されている請求項３に記載の触感フィードバックタッチ制御機器。
【請求項９】
前記アクチュエータは、回転方向の自由度に出力を与えるロータリアクチュエータであり、該出力される力は、前記直線の力に変換される請求項８に記載の触感フィードバックタッチ制御機器。
【請求項１０】
前記アクチュエータは、Ｅコアアクチュエータである請求項８に記載の触感フィードバックタッチ制御機器。
【請求項１１】
前記アクチュエータは、該アクチュエータの支持板を前記アクチュエータの磁石に対応して滑らせる少なくとも一つのローラを有する請求項１０に記載の触感フィードバックタッチ制御機器。
【請求項１２】

前記アクチュエータは、前記支持板と前記磁石との間にバネ復元力を与えるフレキシャを有する請求項１１に記載の触感フィードバックタッチ制御機器。
【請求項１３】
前記アクチュエータは、前記タッチ入力装置を横方向に振動させるものである請求項１１に記載の触感フィードバックタッチ制御機器。
【請求項１４】
前記タッチ入力装置は、複数の異なる領域を含み、該複数の領域の少なくとも一の領域は前記位置信号を与えるものであり、該複数の領域のその他の領域の少なくとも一の領域は異なる機能を制御するために前記コンピュータによって使用される信号を与えるものである請求項１１に記載の触感フィードバックタッチ制御機器。
【請求項１５】
前記複数の領域の少なくとも一の領域は、前記複数の領域の別の一の領域よりもむしろ、前記タッチ入力装置上への異なる触感出力に関連付けられる請求項１４に記載の触感フィードバックタッチ制御機器。
【請求項１６】
触感覚が、前記ユーザが前記複数の領域の一の領域から、他の一の領域に向けて接触する物体を動かす際に出力されるものである請求項１４に記載の触感フィードバックタッチ制御機器。
【請求項１７】
前記アクチュエータは、第一のアクチュエータであり、少なくとも前記タッチ入力装置に連結された別の一のアクチュエータを更に備えており、これらアクチュエータは、プリント回路基板に面実装されたＥコアアクチュエータである請求項１に記載の触感フィードバックタッチ制御機器。
【請求項１８】
コンピュータに信号を入力するとともに、ユーザに力を出力する触感フィードバックタッチ制御機器であって、
該制御機器は、前記ユーザが押す場所を二次元で表す位置信号を与える略平面状のタッチ面を有するタッチ入力装置と、該タッチ入力装置に近接して配置された面と、該面に連結された少なくとも一つのアクチュエータとを備え、
前記コンピュータは、前記位置信号に由来する位置情報を受け取るものであり、前記アクチュエータは、前記面に触れるユーザに対して触感を与えるべく前記面に力を出力すると共に、前記コンピュータにより出力される力の情報に基づいて前記力を出力するものである触感フィードバックタッチ制御機器。
【請求項１９】
前記面は、前記タッチ面に略平行な平面中で横方向に移動するものである請求項１８に記載の触感フィードバックタッチ制御機器。
【請求項２０】
前記面は、前記タッチ入力装置に位置合わせされており、前記ユーザが該面を押すことで前記タッチ入力装置が押されるように、少なくとも前記タッチ入力装置の面と略同一の広がりを有するものである請求項１９に記載の触感フィードバックタッチ制御機器。
【請求項２１】
前記アクチュエータは、リニアアクチュエータである請求項２０に記載の触感フィードバックタッチ制御機器。
【請求項２２】
前記アクチュエータは、ロータリアクチュエータであり、その連結部材は、回転方向に出力される力を前記移動する面に対する略直線方向に出力される力に変換するものである請求項２０に記載の触感フィードバックタッチ制御機器。
【請求項２３】
前記アクチュエータは、ボイスコイルアクチュエータであり、その巻き線は物理的に前記面に連結されている請求項１８に記載の触感フィードバックタッチ制御機器。

【請求項２４】
前記面は、前記ユーザが該タッチ入力装置を一本の指で触れると同時に該面を別の指又は手のひらで触れ得るように、前記タッチ入力装置の側部に位置している請求項１８に記載の触感フィードバックタッチ制御機器。
【請求項２５】
前記面は、前記タッチ入力装置に近接して配置されている物理ボタン上に配置されている請求項２１に記載の触感フィードバックタッチ制御機器。
【請求項２６】
前記面に対する前記力は、該面の表面に略垂直に出力される直線の力である請求項１８に記載の触感フィードバックタッチ制御機器。
【請求項２７】
前記直線の力は、前記アクチュエータを有すると共に質量体を移動させるアクチュエータアセンブリにより出力される慣性力であり、該慣性力は、前記面を介して該面に触れているユーザに伝達されるものである請求項２６に記載の触感フィードバックタッチ制御機器。
【請求項２８】
前記面は、前記コンピュータのハウジングに連結されると共に前記タッチ入力装置の側部に配置されている手のひら面である請求項１８に記載の触感フィードバックタッチ制御機器。
【請求項２９】
前記コンピュータに備えられた音響電子機器が前記少なくとも一つのアクチュエータを駆動するために使用される請求項１８に記載の触感フィードバックタッチ制御機器。
【請求項３０】
直線出力を与えるアクチュエータであって、
該アクチュエータは、二つのポールの間に配置された中央のポールを有する閉じた強磁性部材と、該中央のポールに巻き付いたコイルと、前記中央のポールと二つのポールに近接して位置する磁石と、該磁石に連結された支持板とを備え、
エアギャップが、該磁石と前記強磁性部材との間に設けられており、前記支持板は、前記コイルに電流が流れたときに前記閉じた強磁性部材に追従して動くものであるアクチュエータ。
【請求項３１】
前記支持板と前記強磁性部材との前記相対運動を促すべく、前記強磁性部材と前記支持板との間に位置するローラ群を更に備えている請求項３０に記載のアクチュエータ。
【請求項３２】
前記ローラ群は、保持器により保持されている請求項３１に記載のアクチュエータ。
【請求項３３】
前記支持板と前記強磁性部材との間に連結されたフレキシャを更に備え、該フレキシャは、前記支持板と前記強磁性部材の望まない方向への相対運動を規制すると共に、前記支持板と前記強磁性部材との間に中央への弾性付勢力を与える請求項３０に記載のアクチュエータ。
【請求項３４】
前記アクチュエータの全厚が略４ｍｍ又はそれ以下である請求項３０に記載のアクチュエータ。
【請求項３５】
触感タッチパッド装置であって、
該触感タッチパッド装置は、セラミック製の部材に連結された金属ダイヤフラムを有する、（他の装置に）取り付けられた圧電変換器と、ユーザが触れる場所を検知すると共に、コンピュータの制御機器に前記場所を示す情報を与える平面状のセンサと、前記圧電変換器と前記平面状のセンサとの間に設けられると共に、前記金属ダイヤフラムが接触するスペーサと、前記平面状のセンサと前記取り付け部との間に連結されると共に、バネ復元力

を前記平面状のセンサに与えるバネ部材とを備えている触感タッチパッド装置。
【請求項３６】
前記圧電変換器は、前記触感タッチパッド装置の固有振動数近傍の信号により駆動されるものである請求項３５に記載の触感タッチパッド装置。
【請求項３７】
前記固有振動数は、前記バネ部材のバネ定数を調整するか、又は、前記スペーサ若しくは前記平面状のセンサ部材の質量を調整することにより調整され得るものである請求項３５に記載の触感タッチパッド装置。
【請求項３８】
グラフィック環境を提供するコンピュータ装置に入力を与えるタッチ入力装置に触感フィードバックを与える方法であって、
該方法は、前記タッチ入力装置から、該タッチ入力装置の面上の前記ユーザの触れている場所を示す位置信号を受け取る過程と、
前記ユーザの触れている場所が位置する領域を複数の領域から決定する過程と、
前記タッチ入力装置の前記面は、前記複数の領域に分けられ、少なくとも一つのアクチュエータから、前記タッチ入力装置を操作している前記ユーザに力を出力させるように、力の情報を与える過程とを備え、
前記力は、前記タッチ入力装置の前記面に接した状態で又はその上方に離間した状態で物体を動かしている前記ユーザに関連付けられている方法。
【請求項３９】
前記ユーザの触れている場所が位置する前記領域に関連付けられた機能を提供する過程を更に含む請求項３８に記載の方法。
【請求項４０】
前記領域に関連付けられている前記機能は、ある値の速度制御の機能を含む請求項３９に記載の方法。
【請求項４１】
前記領域に関連付けられている前記機能は、前記位置信号に基づいた画面位置に向けて画像表示されているカーソルを動かす操作を含む請求項３９に記載の方法。
【請求項４２】
前記機能は、前記コンピュータ装置上で実行されるアプリケーションプログラムにより表示される画像ボタンを選択することによっても開始され得る機能を有する前記領域に関連付けられる請求項３９に記載の方法。
【請求項４３】
前記力は、前記ユーザが前記タッチ入力装置の異なる領域から前記ユーザの触れている場所が位置する領域に向けて境界を超えて前記物体を動かすときに出力されるものである請求項３８に記載の方法。
【請求項４４】
前記物体は、前記ユーザの指又は前記ユーザに保持された物体を含み、前記タッチ入力装置の前記面に接した状態で又はその上で離間した状態で動いたものである請求項３８に記載の方法。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、コンピュータと機械的装置とのユーザによるインターフェイスに関するものであり、更に詳しくは、コンピュータシステムと電子機器のインターフェイスに使用される装置に関する。
【背景技術】
【０００２】
人は、多様な応用例において、電子的又は機械的装置とのインターフェイスをとっており、より自然で、取り扱い容易で、情報量の豊かなインターフェイスが絶えず要望されてい

る。本発明の背景には、人が多様な用途のためにコンピュータ装置とのインターフェイスをとっている事実が存在しているのである。かかる用途の一例として、ゲーム、シミュレーション、アプリケーションプログラム等、コンピュータにより創生される環境とのインタラクションがある。マウスやトラックボール等のコンピュータ入力装置は、グラフィック環境中でカーソルを手繰るためにしばしば使用され、これら用途の中で入力手段を提供している。

【０００３】

ある種のインターフェイス装置においては、フォースフィードバックや触覚フィードバックもまたユーザに与えられており、これらはいわゆる触感フィードバックとして知られている。例えば、触感対応型のジョイスティック、マウス、ゲームパッド、ハンドル、その他の種類の装置は、ゲームやその他のアプリケーションプログラム等のグラフィック環境中で起こるイベントやインタラクションに基づいて、ある種の力をユーザに出力することができる。

【０００４】

携帯用コンピュータや電子機器、例えば、ラップトップコンピュータにおいては、マウスは、一般にあまりに大きな作業領域を占め過ぎているため、実用性を損なっている。その結果、よりコンパクトな装置であるトラックボールがしばしば使用されている。最近では、携帯コンピュータ用として更に人気を博しているものとして、いわゆるタッチパッドがある。該タッチパッドは、コンピュータのキーボードの近傍に配されている小四辺形状且つ平面状のパッドであり、多様なセンサ技術のいずれか、例えば、タッチパッドに付与される圧力を検知する静電容量検知センサや圧力検知センサを利用して位置決め用物体の位置を検知するものである。ユーザは大抵、該タッチパッドに指先で触れ、該パッド上で指を動かすことにより、グラフィック環境中に出現しているカーソルを動かす。別の形態においては、ユーザはタッチパッドにペン先をあてがって該タッチパッド上でペン先を押しつけながら動かすことができる。かかるタッチパッドと類似の装置であるタッチスクリーンは、表示スクリーンに重ね合わせて配置されたセンサパッドに情報を入力するものである。このタッチスクリーンは、いわゆる携帯情報端末（ＰＤＡ）や、その他の携帯電子機器に使用されている。

【０００５】

タッチパッドとスクリーンにおける一つの問題点は、ユーザに触感フィードバックが何ら与えられていない点である。そのため、タッチバッドのユーザは、ユーザを補助し、グラフィック環境中でターゲティングやその他の制御タスクに関する情報を提供する触感を感じることができない。また、従来技術におけるタッチパッドは、コンピュータ上で実行される、触感覚を可能とした現状のソフトウエアに対しても優位に立つことができない。

【発明の開示】

【発明が解決しようとする課題】

【０００６】

本発明は、コンピュータシステムに入力を与えるための触感フィードバック平面状タッチ制御機器に関するものである。該制御機器は、携帯用コンピュータに設けられたタッチパッドや、多様な装置上で見出されるタッチスクリーンになり得るものである。該タッチ制御機器に出力される触感により、グラフィック環境中や電子機器を制御する際のインタラクションや操作が強調されるようになる。

【課題を解決するための手段】

【０００７】

より詳細には、本発明はコンピュータに信号を入力すると共に、ユーザに力を出力する触感フィードバックタッチ制御機器に関するものである。該制御機器は、ユーザが触れる位置に基づいて前記コンピュータのプロセッサに位置信号を入力するための略平面状のタッチ面を有するタッチ入力装置を備えている。一以上のアクチュエータが、前記タッチ面に触れるユーザに触感を与えるべく該面に略平行に該タッチ入力装置を横方向に動かす力を出力し得るように、前記タッチ入力装置に連結されている。前記コンピュータは、前記位

置信号に基づいて、表示装置に表示されるグラフィック環境中にカーソルを位置させることができる。前記タッチ入力装置は、別体のタッチパッドとすることもできるし、タッチスクリーンに含ませることもできる。

【０００８】

別の形態においては、触感フィードバックタッチ制御機器は、コンピュータプロセッサに位置信号を入力する略平面状のタッチ面を有するタッチ入力装置を備え、一の面が、前記タッチ入力装置に近接して配置されており、ここで、ユーザは、タッチ入力装置を押しているときに該面に触れることができ、そして、一のアクチュエータが前記面に連結されている。該アクチュエータは、前記面に力を出力することにより前記ユーザに触感を与える。前記面は、前記タッチ入力装置の表面に略平行な平面上で横方向に移動し得るものである。例えば、前記面は、前記タッチ入力装置に位置合わせされ、該タッチ入力装置の表面と同一の広がりを有するものとするか、又は、前記面は、ユーザが該タッチ入力装置を一本の指で触れると同時に、該面をそれと異なる指と手のひらで触れるように、前記タッチ入力装置の側部に配置することができる。例えば、前記面は、前記タッチ入力装置に近接して配置されている物理ボタンに位置合わせされ得るものである。前記面には、押圧力又は慣性力を出力することができる。

【０００９】

本発明の別の態様においては、アクチュエータが直線の力を出力すると共に、二つの側ポールの間に配置された中央のポールを有する強磁性体の部材を含んでおり、コイルが中央のポールに巻き付いており、磁石が前記中央のポールと二つの側ポールに近接して配置され、支持板が前記磁石に連結されており、前記支持板と前記磁石は、前記コイルに電流を流した際に前記強磁性体の部材に追従して動く。前記強磁性体の部材と支持板との間には、該運動を促すようにローラ群を配置し得る。フレキシャが支持板と強磁性体の部材との間の望ましくない方向へ相対運動を規制し、中央への弾性付勢力を与え得る。

【００１０】

別の態様では、タッチ入力装置は、セラミック製の部材に連結された金属ダイヤフラムを有する、（他の装置に）取り付けられた圧電変換器と、タッチパッド等の平面状のセンサ部材とを備える。スペーサが前記圧電変換器と前記平面状のセンサとの間に設けられており、金属ダイヤフラムが該スペーサーに接触している。バネ部材が前記平面状のセンサ部材にバネ復元力を与えている。

【００１１】

本発明の別の態様は、タッチ入力装置に触感フィードバックを与える方法であって、前記ユーザが触れている面上の場所を示す位置信号を前記タッチ入力装置から受け取り、該面上の複数の領域の内から、ユーザの触れている場所が位置する領域を決定する過程を備える方法である。出力される力は、前記タッチ入力装置の前記面に接した状態で又はその上方で離間した状態で物体を動かしている前記ユーザに関連付けられている。ある機能、例えば、ある値の速度制御の機能又は画像表示されているカーソルを動かす操作、が前記ユーザの触れている場所が位置する領域に関連付けられ得る。前記力は、前記ユーザが前記タッチ入力装置の異なる領域から前記ユーザの触れている場所が位置する領域に向けて境界を超えて前記物体を動かすときに出力され得る。

【発明の効果】

【００１２】

本発明によれば、タッチパッドやタッチスクリーン等、コンピュータにおける平面状のタッチ入力装置に触感フィードバックを与えることができる。該触感フィードバックは、画像インターフェイスやその他環境中におけるイベントやインタラクションの情報をユーザに与え、ユーザを補助することができる。更に、本発明は、携帯用コンピュータ装置にそのようなタッチ制御機器を装備させることで、従来の触感フィードバック対応のソフトウエアに対して優位に立たせることができる。本発明で開示される前記触感タッチ装置は、安価、コンパクト、且つ消費パワーが小さいものであり、多種多様な携帯用又はデスクトップコンピュータや、電子機器に組み込み可能なものとなる。

【００１３】
上述のそしてその他の本発明による有利な効果は、以下の記述と図面を参照することによって当業者に明らかとなる。
【発明を実施するための最良の形態】
【００１４】
図１は、本発明のタッチパッド（タッチ入力装置）を含む携帯用コンピュータを示す斜視図である。コンピュータ１０は、ユーザにより運搬されるか或いは移動させられ、電池又は携帯エネルギー源その他の静的エネルギー源によって電源が供給される携帯用コンピュータやラップトップコンピュータである。コンピュータ１０は、好ましくは周辺機器を通じてユーザが利用する一以上のホストアプリケーションプログラムを実行させるものである。
【００１５】
コンピュータ１０は、図１に示すように、多様な入出力装置を含み得るものであり、例えば、ユーザに画像イメージを出力するための表示装置１２と、ユーザからコンピュータに向けて文字やトグル入力を与えるためのキーボード１４と、本発明のタッチパッド１６を備えるものである。表示装置１２は、多種ある表示装置のいずれでも良く、平面表示装置は、携帯用コンピュータでは最も一般的なものである。表示装置１２は、コンピュータ１０のＣＰＵで実行されるアプリケーションプログラム及び／又はオペレーティングシステム、例えば、グラフィカルユーザインターフェイス（ＧＵＩ）に基づいてグラフィック環境１８を表示し得る。ＧＵＩは、ユーザの入力により動かし得るカーソル、並びにウインドウ２２、アイコン２４、その他のＧＵＩ環境中で良く知られる画像部品を含み得るものである。その他のグラフィック環境や図柄、例えば、ゲーム、映画、その他の表現、表計算ソフトやその他のアプリケーションプログラム等もまた画像表示し得る。
【００１６】
コンピュータ１０には、その他の装置、例えば、記憶装置（例：ハードディスクドライブ、ＤＶＤ－ＲＯＭ等）、ネットワークサーバー又はクライアントサーバー、ゲームコントローラ等を組み込み、連結し得る。その代わりに、コンピュータ１０は、卓上用又はその他の面上に置かれるコンピュータ装置を含み、ゲームセンターの据え置き型ゲーム機、その他の携帯用装置、又は個人使用の装置、例えば、片手で使用又は取り扱える装置を含む多様な形態を取り得る。例えば、ホストコンピュータ１０は、ビデオコンソール、パソコン、ワークステーション、テレビ受像機の「セットトップボックス」や「ネットワークコンピュータ」、又はその他の計算若しくは電子機器になり得るものである。
【００１７】
本発明におけるタッチパッド装置１６は、従来技術のタッチパッドと外見上似たものであることが好ましい。ここに含まれる多数の形態において、例えば、図１に示すように、パッド１６は、平面状の、四辺形状（又はその他の形状）の平滑な面を含むものであり、コンピュータ１０のハウジング上におけるキーボード１４の下方に配置され得るか、又は前記ハウジングのその他の領域に配置され得るものである。ユーザがコンピュータ１０を動かすとき、ユーザは、タッチパッド１０上に指先やその他の物体を容易に配置することができ、指先を動かすことでグラフィック環境１８中でカーソル２０を動かすことができる。
【００１８】
作動時においては、タッチパッド１６は、該タッチパッド上で（又は近傍で）検知した物体の位置に基づいて、コンピュータ１０のメインのマイクロプロセッサに座標データを入力する。従来技術の多くのタッチパッドと同様に、タッチパッド１６には、容量性、抵抗性、又は異なる種類のセンサを利用することができる。容量性のタッチパッドは、一般的に、タッチパッドと物体との間に形成されるコンデンサの静電容量に基づいて、タッチパッドの面上又は近傍の前記物体の位置を検知するものである。抵抗性のタッチパッドは、一般的に圧力検知であり、これによれば、該パッドに対して指、ペン先、又はその他の物体が触れることにより、導電性のレイヤー、軌跡、スイッチ等を生じて電気的接点を形成

する。ある種の抵抗性又はその他の種類のタッチパッドは、ユーザにより付与される圧力の量を検知し得るものであり、コンピュータ１０に比例的に、又は可変に入力される圧力の程度を利用し得るものである。抵抗性のタッチパッドは、一般的に少なくとも一部が変形し得るものであり、それにより、ある特定される場所に圧力が付与されたとき、その場所における導電体が電気的接点に至らせる。このように変形し得ることは、パルスや振動等、タッチパッド上に出力される力の程度を増幅し得るため、本発明において有用となり得る。力は、アクチュエータと動かされる物体との間に程よく調整されたサスペンションが付与されたときに増幅され得るものである。容量性のタッチパッド及びその他の種類のタッチパッドで、強い接触力を必要としないものは、本発明のある形態において、より適したものである。その理由は、タッチパッドに過度の圧力が加えられることで、触感フィードバックのためのタッチパッドの動きが妨害される場合があるからである。タッチパッドには、その他の種類のセンサ技術を利用することもできる。ここで、「タッチパッド」なる用語には、タッチパッドユニットに含まれている任意のセンサ機構同様、タッチパッド１６の面が含まれていることが好ましい。

【００１９】

タッチパッド１６は、該タッチパッド上で指先が動く速さがグラフィック環境中でカーソルが動く距離に関連付けられている現行のタッチパッドと同様に作動する。例えば、ユーザがその指をパッド上で素早く動かした場合、ユーザは、より遅い速さで指先を動かした場合と比べ、カーソルは、より長い距離を移動する。ユーザの指が、その指を動かす方向における所望位置に到達する前にタッチパッドの縁に到達した場合、ユーザは、その指をタッチパッドから離すだけでよく、その縁から正常な位置に戻し、カーソルを動かし続けることができる。これはマウスの位置とカーソルの位置との間のオフセット量を変更するべくマウスを面から持ち上げる動作と類似した「インデクス」機能である。更に、多くのタッチパッドには、カーソルの位置とは無関係となり得る特定の機能にそれぞれ割り当てられた特別な領域を設け得る。そのような形態については、後で図１８に関連させてより詳細に説明する。ある形態では、タッチパッド１６は、コマンドを与えるためにある特定の場所において、ユーザにタッチパッドを「タップ」（素早く物体をパッドに接触させ、該物体を取り除くこと）させるもできる。例えば、ユーザは、カーソルの制御が終了してアイコンが選択されている間、指によってパッドをタップするか又は「２回タップ」することができる、

【００２０】

本発明において、タッチパッド１６には、該タッチパッド１６に物理的に触れているユーザに触感覚の如き触感フィードバックを出力する機能を設け得る。触感フィードバックタッチパッドの詳細な構造を有する多様な形態については、以下により詳細に説明される。ある形態では、タッチパッド自体ではなく、装置のハウジング又は別体の可動の面を動かしたりする場合がある。

【００２１】

タッチパッド１６に連結された一以上のアクチュエータ、又は関連付けられた面を使用することにより、多様な触感をタッチパッド（又はハウジング、又は別体化された面）に触れているユーザに出力することができる。例えば、衝撃、振動（変化するものか又は一定の強度の）、そして手触りが出力され得る。ユーザに出力される力は、少なくとも一部をパッド上の指の位置、若しくはホストコンピュータ１０のグラフィック環境中における被制御物体の状態に基づくものとする、及び／又は、指の位置又は物体の状態に無関係とすることができる。ユーザに出力されるそのような力は、マイクロプロセッサ又はその他の電子制御機器が、電子的信号を使用してアクチュエータにより出力される力の強度及び／又は方向を制御しているため、「コンピュータの制御下にある」と考えられる。

【００２２】

他の形態においては、タッチパッド１６は、ケーブル又はワイヤレス伝送装置を介してコンピュータ１０の入力端子に接続される別体化されたハウジングに設けられる。そして、該タッチパッド１６は、前記コンピュータ１０から力の情報を受け取り、コンピュータ１

０に位置の情報を伝える。例えば、ユニバーサルシリアスバス（ＵＳＢ）、ファイヤワイヤ、又は標準シリアスバスによって、コンピュータ１０にそのようなタッチパッドを接続することができる。

【００２３】

一以上のボタン２６を、タッチパッド１６と関連させるべく、コンピュータ１０のハウジングに設けることができる。ユーザは、手によって容易にこのボタンに触れることができ、これらボタンのそれぞれは、ユーザにより押され、ホストコンピュータ１０に明瞭な出力信号を与えることができる。一般的には、それぞれのボタン２６は、マウス入力装置上で見出される類似のボタンに対応するものであり、即ち、左側のボタン（クリック又はダブルクリック）は画像物体を選択するために用いられ得るものであり、右側のボタンは、コンテキストメニュー等を提示し得るものである。ある形態では、一以上のボタン２６は、触覚フィードバックを備えることができる。

【００２４】

更に、ある形態では、コンピュータ装置１０のハウジングに一以上の可動部分２８を設け得るものとなる。該可動部分２８は、ユーザがタッチパッド１６を操作して触れたときに、ユーザに触感フィードバックを与え得るものである。触感フィードバック用にハウジングに可動部分を設けた形態は、米国特許第６，１８４，８６８号及び第６，０８８，０１９号に記載されている。ある形態では、いずれのハウジングも触感フィードバックを与えることができ（例えば、ハウジングに連結されたモータに過度の回転質量をかけることによって）、そして、タッチパッド１６は、別々の触感フィードバックを与えることができる。これにより、ホストコンピュータをユーザに２種の異なる触感覚を同時に与えるように制御することができる。例えば、低周波の振動がハウジングを通してユーザに伝えられ、高周波の振動がタッチパッド１６を通してユーザに伝えられ得るものとなる。触感フィードバックを備えたそれぞれのボタン又は制御機器は、その他の制御機器から独立して触感フィードバックを与えることができる。

【００２５】

ホストアプリケーションプログラム及び／又はオペレーティングシステムは、好ましくは、表示装置１２上にグラフィックイメージ環境を表示するものである。ホストコンピュータ１０上で実行されるソフトウエア及び環境は、多岐にわたるものとなり得る。例えば、ホストアプリケーションプログラムとしては、ワープロ、表計算、映画、ビデオ、コンピュータゲーム、描画プログラム、オペレーティングシステム、画像インターフェイス、シミュレーション、ＨＴＭＬ又はＶＲＭＬの使用説明を含むウエッブページやブラウザ、科学分析プログラム、仮想現実訓練プログラム若しくはその応用、又は、タッチパッド１６から入力し、タッチパッド１６に触感フィードバックコマンドを出力する形式を利用するその他のアプリケーションプログラムが挙げられる。例えば、力（フォース）フィードバック機能性を有する多くのゲームやその他のアプリケーションプログラムが挙げられ、そして、カリフォルニア州サンノゼのイマージョン社から利用できるＩ－Ｆｏｒｃｅ（登録商標）、ＦＥＥＬｉｔ（登録商標）、又はTouchsense（登録商標）等の標準的なプロトコル／ドライバを使用してタッチパッド１６に伝達する。

【００２６】

タッチパッド１６には、ホストコンピュータ１０のマイクロプロセッサに制御信号を伝え、ホストコンピュータのマイクロプロセッサからのコマンド信号を処理するのに必要な回路を設け得る。例えば、適当なセンサ（及び関連する回路）がタッチパッド１６上のユーザが触れる位置を伝えるために使用される。前記タッチパッド装置は、ホストコンピュータから信号を受け取り、一以上のアクチュエータを使用して、前記ホストコンピュータの信号に従って、触感覚を出力する回路を備えることができる。ある形態では、別体化された、タッチパッドセンサデータをホストコンピュータに伝えると共に／又はホストコンピュータから受け取った力コマンドを実行するために、ローカルマイクロプロセッサをタッチパッド１６に設け得る。このようなコマンドは、例えば、触感の種類や、伝達された触感を表すパラメータを含むものである。或いは、タッチパッドのマイクロプロセッサは、

メインプロセッサからアクチュエータに向けたデータを通過させるのみである。「力の情報」なる用語には、コマンド／パラメータ、及び／又はストリームされたデータが含まれ得るものである。タッチパッドマイクロプロセッサは、ホストコマンドを受け取った後にタッチパッドアクチュエータを制御することにより独立して触感を提供し得るものである。或いは、ホストプロセッサは、アクチュエータをより直接的に制御することにより、触感をより強く制御する状態を維持し得るものとなる。他の形態においては、タッチパッド１６のために設けられたステート・マシン等のロジック回路は、ホストメインプロセッサによって管理される触感を処理することができる。センサ信号を読み取り、装置に触感フィードバックを与えるために使用し得る構成及び制御方法は、米国特許第５，７３４，３７３号により詳細に記載されている。

【００２７】

従来のタッチパッドの形態においては、シナプティクス社製のものに、特有の特徴と機能が設けられている。タッチパッド用の標準的な面材料は、マイラー織物であり、一般的に非電気伝導性の物体であればタッチパッドの面に使用することができ、ユーザの指が指し示すことに使用されたとき、織物の面を通じて検出され得るものとなる。タッチパッドは、薄いオーバーレイを通しても検知することができる。触感フィードバックの構成部品用の補助部材のために一般に使用できるスペースとしては、例えば、４０×６０のタッチパッド上では、半分以上の基板が触感回路のために利用できる。

【００２８】

多くのタッチパッドは、「手のひら照合」の機能を有しており、これにより、ラップトップに、ユーザが指、手のひら、又は手のその他の部位のいずれでタッチパッドに触れているかを検知させることができる。ユーザは手のひらを載置しているのみであり、入力を与えようとする意思はないので、前記手のひら照合の機能は、ユーザの手のひらにより与えられたと決定された入力を無視する。基本的には、前記手のひら照合の機能は、導電性の物体（指、手のひら、腕等）により形成される接触領域の広さを計算する。該接触領域が所定の閾値を越えた場合には、接触が拒絶される。この機能は、多くの形態において途中で停止することができる。

【００２９】

図２は、装置３０の別の形態を示す斜視図であり、本発明のアクティブタッチパッド１６を含み得るものである。該装置は、手で保持できる遠隔リモコン装置３０となり得るものであり、それは、電子機器、又はユーザにより遠隔操作される機器（例えば、テレビ受像機、ビデオ、カセットコーダ若しくはＤＶＤプレイヤー、オーディオ／ビデオレシーバ、テレビ受像機等に接続されるインターネット若しくはネットワークコンピュータ等）の諸機能にアクセスするべく、ユーザが片手で保持しつつ手で操作するものである。例えば、数個のボタン３２は、制御される機器の諸機能を操作するべく、リモコン装置３０に設け得るものである。タッチパッド１６は、ユーザによって更に洗練された方向付けを与える入力を可能とするために設けられる。例えば、制御される機器は、カーソルが移動する選択画面を有しており、そして、タッチパッド１６は、二次元の方向に該カーソルを動かすように操作し得るものである。タッチパッド１６は、制御された値又はイベントに基づいて、ここに説明されるようなユーザに触感を出力する能力を有するものである。例えば、ボリュームレベルが中間点を経るか又は最大レベルに到達すると、タッチパッドに出力されるパルスを生じ、ユーザに伝えられ得る。

【００３０】

一つの適用例においては、前記制御される機器は、マイクロソフト社のウエッブＴＶ等のコンピュータ装置、又はインターネット等のネットワークを介してアクセスされるウエッブページ及び／又はグラフィックユーザインターフェイスを表示するその他のコンピュータ装置となり得るものである。ユーザは、指（又はその他の物体）をタッチパッド１６上で動かすことにより、カーソルの方向を制御することができる。該カーソルは、アイコン、ウィンドウ、メニューアイテム、画像ボタン、スライダーバー、スクロールバー、又はグラフィックユーザインターフェイス若しくはデスクトップインターフェイスにおけるそ

の他の画像物体の操作及び／又は選択のために使用される。該カーソルは、例えば、リンク、図柄、ボタン等のウエッブページ上の画像物体を選択するか、又は操作するためにも使用される。画像物体に関連付けられるその他の力触感は、図１８を参照しながら以下に記述される。

【００３１】

図３は、本発明における触感装置のいずれの形態をも含み得る別のコンピュータ装置の形態５０を示す平面図であり、該装置５０は、「携帯情報端末」（ＰＤＡ）、「ペンベース」コンピュータ、「ウエッブパッド」、「電子手帳」、又は類似の装置（これらは、総括して「携帯情報端末」（ＰＤＡ）として知られている。）等の携帯用コンピュータ装置の形態を呈するものである。これら装置は、ユーザを表示スクリーンに触れさせることにより情報を入力させるか、又は、ある形式での読み出しを行わせるものであり、ボタン入力を可能とする装置と同様に、本発明に関連するものである。このような装置は、３ＣＯＭ社製のパームパイロット（登録商標）又は類似製品、カシオ社製、ヒューレットパッカード社製、その他のメーカー製のポケットサイズのコンピュータ装置、電子書籍、タッチスクリーンを有する携帯電話若しくはポケベル、タッチスクリーンを有するラップトップコンピュータ等を含み得るものである。

【００３２】

装置５０の一の形態においては、ハウジング５４に近接して配置された表示スクリーン５２は、コンピュータ装置５０の大部分の面をカバーするものである。スクリーン５２は、好ましくは、当業者に良く知られた平面パネルディスプレイ装置であり、文字、図柄、アニメーション等を表示し得るものである。ある形態では、スクリーン５２は、パソコンの画面と機能的に同等なものである。表示スクリーン５２は、スクリーン５２を物理的に触れることにより、コンピュータ装置５０（例えば、これは、図１に示すタッチパッド１６に類似した平面的な「タッチ装置」の別の形態を示すものである。）にユーザをして入力の情報を与えさせるセンサを有する「タッチスクリーン」になり得るものである。例えば、透明なセンサフィルムをスクリーン５２上に被せることができ、フィルムに触れる物体の圧力を検出し得るものとなる。タッチスクリーンを提供するセンサ装置は、当業者によく知られたものである。

【００３３】

ユーザは、画像物体が表示されている正確な場所におけるスクリーン５２に対して指先又はペン先を押すことにより、画像に表示されているボタン又はその他の画像物体を選択することができる。更に、ある形態では、ペン先の先端、例えば、ペン先５７、又は指、又はその他の物体をユーザが押しつけた場所にグラフィック「インク」イメージ５６を表示することによってスクリーン上で「図を描く」又は「文字を書く」動作をユーザに可能とさせ得る。手書きで描画された文字は、コマンド、データ、又はその他入力として、装置のマイクロプロセッサ上で実行されるソフトウエアによって認知され得る。他の形態では、ユーザは、補助的又は代替的に音声認知を通して入力を行うことができる。ここで、装置上のマイクロフォンには、ユーザの音声が入力され、該音声は、該装置上で実行されるソフトウエアによってしかるべきコマンド又はデータに変換される。物理ボタン５８もまた、該ボタンが押されたときに装置５０に特定されるコマンドを与えるべく装置５０のハウジングに設け得る。多くのＰＤＡは、ユーザの文字入力用の標準的なキーボードがないことで特徴付けられ、むしろ、スクリーン上に文字を描画するペン先を使用することや、音声認知等の代替的な入力様式が使用される。しかしながら、あるＰＤＡは、タッチスクリーンと並んで全ての機能を有するキーボードを備えており、該キーボードは、一般的に標準サイズのキーボードに比してかなり小さいものである。更に別の形態においては、標準的なキーボードを有する標準サイズのラップトップコンピュータに平面パネルタッチ入力表示スクリーンが設けられ、該スクリーン（図１に示すスクリーン１２と類似したスクリーン）には、本発明に従って触感フィードバックを設け得るものとなる。

【００３４】

本発明のある形態では、タッチスクリーン５２は、前記した形態で説明したタッチパッド

１６に類似した触感フィードバックをユーザに与えるものである。一以上のアクチュエータが、前記タッチスクリーンに連結され、又は後述する形態に類似した態様でタッチスクリーンの近傍で可動のスクリーンを形成する。ユーザは、指又はスクリーン５２に接触しているペン先５７等の保持された物体を通して触感フィードバックを感じることができる。

【００３５】

前記タッチスクリーン５２は、ｚ軸に略沿ったスクリーンの動きを許容するべく一以上のバネ又は規格部品、例えば、つる巻きバネ、重ね板バネ、フレキシャ、又は規格材料（発泡体、ゴム等）を介して装置５０のハウジング５４に連結され得るものであり、それにより、触感フィードバックを与えるものである。該スクリーンには、後述する適切な形態に類似して、側部から側部に至る（ｘ及び／又はｙ）動きを可能とするフレキシャ又はその他の連結部材を設け得るものである。

【００３６】

図４は、本発明で説明されるいずれの形態にも適した触感フィードバックシステムを図示するブロックダイヤグラムである。該触感フィードバックシステムは、ホストコンピュータシステム（コンピュータ）７４及びインターフェイス装置（触感フィードバックタッチ制御機器）７２を備えている。

【００３７】

ホストコンピュータシステム７４は、好ましくはホストマイクロプロセッサ１００、クロック１０２、表示スクリーン７６、オーディオ出力装置１０４を備えるものである。該ホストコンピュータは、ランダムアクセスメモリ（ＲＡＭ）、リードオンリーメモリー（ＲＯＭ）、入出力（Ｉ／Ｏ）電子装置（図示せず）等のその他周知の装置も備えるものである。

【００３８】

上述したように、ホストコンピュータ７４は、ラップトップコンピュータ等のパーソナルコンピュータになり得るものであり、いかなる周知のオペレーティングシステム下でも作動するものである。その代わりに、ホストコンピュータシステム７４は、テレビ受像機セットやその他のディスプレイ装置に通常接続される、例えば、任天堂、セガ、ソニー、又はマイクロソフト社製の多種あるホームビデオゲーム機の一つとなり得るものである。他の形態においては、ホストコンピュータシステム７４は、「セットアップボックス」、その他のユーザが入力し得る電子装置になり得るものである。コンピュータ７４は、ＰＤＡ等の小型の携帯用コンピュータにもなり得るものであり、車載コンピュータ、ゲームセンターのゲーム機、ワークステーション等になり得るものである。

【００３９】

ホストコンピュータ７４は、好ましくは、触感フィードバック機能を有するインターフェイス装置７２を介してユーザがインタラクションするホストアプリケーションプログラムを提供することが良い。例えば、該ホストアプリケーションプログラムは、ビデオゲーム、ワープロ、表計算ソフト、ＨＴＭＬ若しくはＶＲＭＬの使用説明を含むウエッブページやブラウザ、科学分析プログラム、映像プレイヤー、仮想現実訓練プログラム若しくはその応用、又はマウス１２からの入力を利用し、前記装置７２に触感フィードバックコマンドを出力するその他のアプリケーションプログラムとなり得るものである。ここで、簡便のため、Ｗｉｎｄｏｗｓ（商標）、ＭＳ－ＤＯＳ、ＭａｃＯＳ、Ｕｎｉｘ、ＰａｌｍＯＳ等のオペレーティングシステムもまた、「アプリケーションプログラム」と呼ばれるものとする。ここで、コンピュータ７４は、「グラフィック環境」を与えるものであり、グラフィックユーザインターフェイス、ゲーム、シミュレーション、又はその他のグラフィック環境になり得るものであり、アイコン、ウィンドウ、ゲーム対象等の画像物体を含み得るものである。コンピュータ出入力（Ｉ／Ｏ）装置とインターフェイスをとるソフトウエアに適したソフトウエアドライバは、カリフォルニア州、サンホセのイマージョン社から購入できる。

【００４０】

ディスプレイ装置７６を、ホストコンピュータ７４に設けることができ、これは、標準表示スクリーン（ＬＣＤ、ＣＲＴ、プラズマ表示装置、平面パネル等）、３-Ｄゴーグル、又はその他いずれかの画像ディスプレイ装置になり得るものである。スピーカ等のオーディオ出力装置１０４は、好ましくは、ユーザに音声出力を与えるべく、ホストコンマイクロプロセッサ１００に接続され得るものである。その他の種類の周辺装置、例えば、記憶装置（例：ハードディスクドライブ、ＣＤ－ＲＯＭドライブ、フロッピー（登録商標）ディスクドライブ等）、その他の入出力装置もまた、ホストプロセッサ１００に接続し得る。

【００４１】

インターフェイス７２は、コンピュータ７４にバス８０によって接続され、装置７２とコンピュータ７４との間で信号をやり取りするものであり、ある形態では、パワーを装置７２に与えるものである。他の形態においては、信号は、無線送信／受信によって装置７２とコンピュータ７４との間を伝送することができる。ある形態では、アクチュエータ用のパワーは、前記装置に設けられた、例えば、コンデンサ又は一以上の電池等のパワー蓄積装置によって補充されるか又は単に供給され得る。バス８０は、ホスト７４と装置７２との間でいずれの方向にも信号を供給するための双方向通信媒体となり得るものである。バス８０は、ＲＳ２３２等のシリアルインターフェイス、ＲＳ-４２２、ユニバーサルシリアルバス（ＵＳＢ）、ＭＩＤＩ、又はその他の当業者に良く知られたプロトコルとすることができ、更には、パラレルバスやワイヤレスリンクとすることもできる。

【００４２】

装置７２は、そのハウジングがホストコンピュータ７４と別体化された装置とすることができ、又は図１に示すラップトップコンピュータにおける如く、ホストコンピュータのハウジングに一体化することもできる。装置７２には、専用のローカルプロセッサ１１０を設けるか、又は関連させることができる。プロセッサ１１０は、装置１２に対してローカルと考えられ、ここで、「ローカル」なる用語は、ホストコンピュータシステム７４においるいずれのホストプロセッサからも分離されたプロセッサであるプロセッサ１１０を指すものである。「ローカル」なる用語は、装置７２の触感フィードバック及びセンサＩ／Ｏに特化されたプロセッサ１１０をも指す場合がある。プロセッサ１１０には、ホストコンピュータ７４からのコマンド又は要求を待って、該コマンド又は要求をデコードし、該コマンド又は要求に従って入出力を処理／制御すべく、ソフトウエア命令（例：ファームウエア）を設け得る。加えて、プロセッサ１１０は、センサ信号を解読し、そしてこれらのセンサ信号、時間信号、ホストコマンドに従って選択された蓄積又はリレー命令からの適切な力を計算することによってホストコンピュータ７４と切り離して作動させ得る。ローカルプロセッサ１１０のような使用に適したマイクロプロセッサには、下級マイクロプロセッサ、並びに、イマージョンタッチセンスプロセッサ等のより洗練された触感フィードバックプロセッサを設け得る。プロセッサ１１０には、一つのマイクロプロセッサチップ、マルティプルマイクロプロセッサ及び／又はコプロセッサチップを設けることができ、デジタル信号プロセッサ（ＤＳＰ）機能、及び／又は、ロジック、ステート・マシン、ＡＳＩＣ等を設けることができる。

【００４３】

プロセッサ１１０は、センサ群１１２から信号を受け取り、バス８０を介してホストコンピュータ７４から与えられる指令に応じてアクチュエータ８８に信号を送ることができる。例えば、ローカル制御形態においては、ホストコンピュータ７４は、バス８０（例えば、コマンド識別子、及び触覚を特徴付ける一以上のパラメータ）を介してプロセッサ１１０に高レベルの監視コマンドを与え、そして、プロセッサ１１０は、該コマンドをデコードし、また、ホストコンピュータ７４と独立して、高レベルコマンドに関連付けてセンサ及びアクチュエータに対する低レベルの力制御ループを管理する。この処理は、米国特許第５，７３４，３７３号に詳しく記載されている。前記ホスト制御ループにおいては、力コマンドがホストコンピュータからプロセッサ１１０に出力され、該プロセッサに特定される性質を有する力又は力感覚を出力させる。ローカルプロセッサ１１０は、ホストコン

ピュータに対して、データ、例えば、一以上の与えられた自由度における装置の位置を表す位置データを伝送する。該データは、ボタン、スイッチ等の状態を表し得るものでもある。前記ホストコンピュータは、履行されたプログラムをアップデートするために該位置データを使用する。ローカル制御ループにおいては、アクチュエータ信号が、プロセッサ１１０からアクチュエータ８８に向けて伝送され、センサ信号が、センサ群１１２及びその他の入力装置１１８からプロセッサ１１０に向けて伝送される。ここでは、「触感覚」なる用語は、ユーザに触感を与えるアクチュエータ８８によって出力される単一の力又は連続した力のいずれかを指すものとする。例えば、振動、単一の衝撃、手触り感は、全て触感覚と見なされる。プロセッサ１１０は、蓄積された命令をフォローすることによって、入力されたセンサ信号を処理して、適正な出力アクチュエータ信号を決定することができる。該プロセッサは、ユーザの使用する物体に出力される力の位置を決定するにあたってセンサ信号を使用し得るものとなり、それと同時にセンサ信号に由来する位置データをホストコンピュータへ伝送する。

【００４４】

更に他の形態では、プロセッサ１１０代替の他のハードウエアを、プロセッサ１１０に類似した機能を与えるべく装置７２の一部に設けることができる。例えば、決まったロジックが組み込まれたハードウエアステート・マシーンは、アクチュエータ８８に信号を送り、センサ群１１２からセンサ信号を受け取り、触覚信号を出力するために使用することができる。

【００４５】

ホストコンピュータにより制御される、異なる形態においては、ホストコンピュータ７４は、バス８０を介して低レベル力コマンドを与えることができ、この信号は、プロセッサ１１０、又はプロセッサ１１０がない場合は、その他の回路を介してアクチュエータ８８に直接伝送される。ホストコンピュータ７４は、このようにして、装置７２とやりとりされる全ての信号を直接制御し処理する。例えば、ホストコンピュータは、アクチュエータ８８により出力される力を直接制御し、センサ群１１２からのセンサ信号を直接受け取り、装置１１８に出力する。他の形態では、ある種の種の力（閉ループ効果）がローカルプロセッサのみによって制御される一方、その他の種類の効果（開ループ効果）が、ホストコンピュータによって制御される「ハイブリッド」構成を採用する。

【００４６】

ローカルメモリ１２２、例えば、ＲＡＭ及び／又はＲＯＭは、好ましくは、プロセッサ１１０へのコマンドを蓄積するべく、装置７２におけるプロセッサ１１０に接続され、一時的なその他のデータを蓄積する。メモリ１２２は、更に又はその代わりに、プロセッサ１１０に含まれ得るものである。加えて、ローカルクロック１２４は、タイミングデータを与えるべく、プロセッサ１１０に接続され得るものである。

【００４７】

センサ群１１２は、望ましい自由度における位置又は動作（例えば、タッチパッド上の物体）を検知し、プロセッサ１１０（又はホストコンピュータ７４）に、前記位置又は動作を代表する情報を含んだ信号を伝える。動作を検知するために適したセンサには、タッチパッドにおける容量性又は抵抗性のセンサ、タッチスクリーンにおける接触センサ等が含まれる。その他の種類のセンサもまた使用し得る。任意のセンサインターフェイス１１４は、センサ信号をプロセッサ１１０及び／又はホストコンピュータシステム７４によって認知される信号に変換するために使用し得る。

【００４８】

アクチュエータ８８は、プロセッサ１１０及び／又はホストコンピュータ７４から受けた信号に応答して、力をハウジング、操作体、ボタン、又はその他の装置７２の部分に伝送する。装置７２は、好ましくは、該装置７２（又は、その構成部品）上でユーザに触感覚を与えるべく力を生成するように作動する一以上のアクチュエータを備えていることが良い。該アクチュエータは、「コンピュータの制御下にあり」、例えば、アクチュエータにより出力される力は、最終的には、マイクロプロセッサ、ＡＳＩＣ等の制御機器に由来す

る信号によって制御される。多くの種類のアクチュエータ、例えば、ロータリＤＣモータ、ボイスコイルアクチュエータ、可動磁石アクチュエータ、Ｅコアアクチュエータ、気圧／流体圧アクチュエータ、ソレノイド、スピーカ音声コイル、圧電変換アクチュエータ、受動アクチュエータ（ブレーキ）等を使用することができる。好ましい種類のアクチュエータのいくつかを、以下に説明する。アクチュエータインターフェイス１１６は、アクチュエータ８８とプロセッサ１１０との間に付加的に接続され、これにより、プロセッサ１１０からの信号をアクチュエータ８８を駆動するのに適した信号に変換し得る。インターフェイス１１６は、パワーアンプ、スイッチ、デジタルアナログ変換器（ＤＡＣ）、アナログデジタル変換器（ＡＤＣ）、及びその他の当業者に良く知られた機器を備え得る。

【００４９】

ここでの実施の態様によっては、アクチュエータは、或いは質量体を動かすことによって、装置のハウジング若しくは操作体上に短時間持続する力感覚を与える機能を有している。この短時間持続する力感覚は、「パルス」と表記される。該「パルス」は、ある形態では特定される方向に実質的に沿うように方向付けされ得る。ある形態では、パルスの強度は制御することができる。即ち、パルスの検知は、正又は負のいずれかのバイアスで制御することができる。つまり、「周期的な力感覚」が適用でき、強度と周波数を有し得るものとなる。この周期的感覚は、例えば、サイン波、矩形波、のこぎり波（上波）、のこぎり波（下波）、及び三角波の中から選択し得るものである。ここで、エンベロープがこの周期的な信号に適用し得るものとなり、時間外の強度変化が可能となる。該波形は、ホストコンピュータから装置に「ストリーム」するものとなり得るか、又は、強度、周波数、及び持続性等のパラメータを含んだ高レベルコマンドを通して伝達され得るものとなる。

【００５０】

他の入力装置１１８を、装置７２に設けることができ、ユーザによって操作されるときにプロセッサ１１０又はホストコンピュータ７４に向けて入力信号を伝送するものとなる。このような入力装置は、ボタン、ダイヤル、スイッチ、スクロール車輪、つまみ、又はその他の制御機器若しくは機構を備えるものである。パワー供給装置１２０は、アクチュエータにパワーを供給すべく、アクチュエータインターフェイス１１６及び／又はアクチュエータ８８に接続して装置７２に補助的に設け得るものである。その代わりに、パワーは、装置７２から別体化されたパワー供給源から引き出し得るか、又は、バス８０を横断して受け取り得る。また、受け取ったパワーは、装置７２（及び／又はホストコンピュータ７４）によって、蓄積されるか又は調節され得るものとなる。そして、アクチュエータ８８を駆動する必要があるとき、又は補助的な態様で使用される。

【００５１】

前記インターフェイス装置７２は、多様な種類を採り得る。ある形態については、以下に更に説明される。ここで説明されるタッチパッド又はタッチスクリーンは、多様な種類の装置、例えば、ゲームパッド、ジョイスティック、舵取りハンドル、タッチパッド、球状のコントローラ、指パッド、つまみ、トラックボール、リモコン装置、携帯電話、携帯情報端末等に設けることができる。

【００５２】

特異な形態

本発明は、ラップトップコンピュータ又はその他の携帯コンピュータ装置のユーザ、及び／又は、タッチパッド又は類似する入力装置を有するコンピュータ装置のユーザに触感フィードバックが与えられる多様な形態を提示する。

【００５３】

ある形態は、ユーザの指がタッチパッドに接触するときに該指の皮膚が移動することに基づいている。これら形態は、ユーザの指の先端において入出力の間に良好な相関関係がある間は、高い忠実度の感覚をもたらす。アクチュエータ及び連結部材による解決法は、移送の形態のいずれも駆動するように説明される。他の形態は、ラップトップコンピュータ１０に通常接触しているユーザの手のひら載置面の刺激に基づいたものである。これら面は、慣性的に結合した力、又は手のひら載置面の移動に基づいて触感覚を与え得るもので

ある。タッチパッド又はラップトップの上面における面の平面移動（例：Ｘ及び／又はＹ軸上）は、触感情報を伝達するに際してＺ軸（タッチパッド又はラップトップの上面に通常な方向）上における振動又は移動と同様に効果的なものである。これは、ラップトップコンピュータの大きさ上の制約を考慮する場合に重要となり得る。

【００５４】

ここで説明される多くの形態の内、ユーザによる接触が、タッチ入力装置により検出されることもまた、有利なものである。その理由は、触感フィードバックは、ユーザがタッチ装置に接触したときにのみ出力される必要があるからであり、この検出により、触感フィードバックがタッチ入力装置に何も接触するものがないときに停止（アクチュエータがオフとなる）する。この特性により、携帯用装置のために電池パワーを保存することができる。もし、タッチ装置マイクロプロセッサ（又は同様の回路）が、コンピュータ内で使用されている場合、このようなマイクロプロセッサは、ユーザの接触が検知されないときにアクチュエータの出力をオフとし得るものとなる。これにより、再度ユーザの接触が再び検知されてアクチュエータが出力を再開する迄、ホストコンピュータの動作の負担が緩和される。

【００５５】

多くの好ましい形態では、触感装置は、ユーザがラップトップコンピュータの操作方法を改めて学習し直すことや、製造者が触感機構を提供するために従来のデザインから過大な変更を強いられることなく、ラップトップコンピュータやその他の装置に付属させるものである。例えば、ラップトップコンピュータの形態においては、ユーザが指をタッチパッドを横切って動かすと、ラップトップのスクリーンに表示されるカーソルは、それに従って移動される。触感効果は、カーソルが画像物体や領域とインタラクトしているとき、イベントが起こっているとき等にユーザが触れているタッチパッド又はその他のラップトップコンピュータの構成部品上に出力することができる。その他の適用例においては、触感効果は、ラップトップコンピュータ上で実行されるゲームやその他のアプリケーションにおいてイベントやインタラクションが起こったときに出力され得る。多くの種のアクチュエータ、センサ、連結部材、増幅伝達装置等は、本発明において使用され得る。

【００５６】

現在製造されているタッチパッドの面は、一般に、ラップトップコンピュータのタッチパッドに連結され、該タッチパッドを作動させるために必要な電子部品と標準的連結部材を備えるプリント回路基板（ＰＣＢ）に接続されている。このため、タッチパッドに力が与えられたとき、この力は、通常タッチパッドに直接接続されている前記ＰＣＢ（例えば、タッチパッドの下部に配置されている）にも与えられる。

【００５７】

ここでの形態は、特別な指針及び特性を考慮して設計されている。例えば、ある形態において強いて感覚される特定の触感、物理的に一点に感触が集中した場所、触感フィードバックと、タッチパッド上でユーザの指が指し示す位置との空間的な相対関係、具体的には、フィードバックが、指の直下にあり得ることであり、又は、ラップトップコンピュータのケース／ハウジングのいずれかの場所で開始すること、必要な力強度及びフィードバックを強いる力、ユーザが装置とインタラクションする方法、及びフィードバックの質と内容に与える効果（指の接触角度等）であり、そして、ラップトップコンピュータの形状因子／ハウジングに適用し得るアクチュエータ及び機構は、最も望ましいものとなる。

【００５８】

好ましくは、ここで説明される形態では、例えば、イマージョン社のタッチセンスソフトウエア等の従来の触感フィードバックソフトウエア及びドライバが使用できることが好ましい。ＰＤＡ装置、ラップトップコンピュータ、携帯電話、リモコン等の多くの異なる種の製品で稼動するある種のタッチパッド等の標準的なモジュールが望ましい。

【００５９】

これら工夫に富んだ形態が目的とするところは、第一には、触覚フィードバックを提供することであって、運動感覚フォースフィードバック形態ではない。ここで説明するように

、本発明に適用される二種の基本的な触覚フィードバックがある。一つは慣性触感フィードバックであり。もう一つは動接触触感フィードバックである。慣性フィードバックは、慣性的に連結された振動を使用することで生成され、適切なフレキシャを通してハウジング／ユーザに連結される質量体を動かすことに基づいたものである。そして、その質量体の動きは、ユーザに接触される面に慣性振動を引き起こす。移動接触フィードバックとは、直接に面又部材を動かすことを指し、地表に対して、ユーザに対向して、通常、ユーザの皮膚を小さく移動させた状態を形成することで生成される。

【００６０】

慣性接触フィードバックと動接触フィードバックとの違いは、ユーザに情報を与えるべく実際に使用された機構の観点から明らかとなり得る。慣性刺激及び触覚刺激の両者は、結果として手又は指の組織を移動させる。即ち、慣性フィードバックは、エンクロージャの伝達性及び該エンクロージャを保持する物体のコンプライアンスに基づいて、該エンクロージャを通して伝達される。動接触フィードバックは、ユーザの組織をいかに刺激するかにおいてより直接的な機構を参照するものである。この実例は、局部的に指又は手のひらの組織を変形することにより感覚を生じさせるべく、指の皮膚を剥ぎ取るような触覚を生じる点又は面であろう。この相違は、以下に説明する二つの種の形態、即ち、慣性及び面移動、を分類する目的にぴったり合致する。

【００６１】

新規なアクチュエータ、ここでフラットＥと呼ぶものは、以下に説明され、ここでの全ての形態において使用でき、極めて低い姿勢、良好なエネルギー効率、高い性能、平面状アクチュエータを表現するものである。フラットＥアクチュエータは、許容できる性能レベルを実現し得るものであり、ラップトップコンピュータ及びその他の装置に必要な限られた容積及び形状因子を満たし得るものである。

【００６２】

慣性の形態

これら形態は、質量体を動かし、ユーザに向けて慣性触感フィードバックを生成するものであり、それは、ハウジングないしはその他の面等の、エンクロージャ又は機構を通して一般に伝達されるものである。多くの場合においては、質量体は、衝撃が代替的に補助的な触感効果を与えるのに用いられる場合でも、移動中にいずれの面にも該衝撃を与えない。

【００６３】

図５は、アクチュエータアセンブリの一形態１５０の斜視図であり、それは、タッチパッド及び本発明における装置のハウジング用に慣性触感を与えるべく使用されるものである。アクチュエータアセンブリ１５０は、下部のフレキシャ１６０及びアクチュエータ１５５を備えている。フレキシャ１６０には、ポリプロピレン樹脂（「一体の蝶番」材料）又はその他の屈曲容易な材料から形成された単一の部材で形成し得る。フレキシャ１６０は、装置７２のハウジングに、例えば部分１６１において取り付け得る。

【００６４】

アクチュエータ１５５は、フレキシャ１６０に連結される。該アクチュエータのハウジングは、図に示すように、アクチュエータ１５５を収納するフレキシャ１６０の収容部１６２に連結されている。該アクチュエータの回転シャフト１６４は、フレキシャ１６０に該フレキシャ１６０の穴で連結され、中央の回転部１７０にしっかりと連結されている。アクチュエータの回転シャフト１６４は、Ａ軸の周りを回転し、該Ａ軸の周りには、部分１７０も回転する。回転部１７０は、フレックスジョイント１７４によって角度部１７１の第一の部分１７２ａに連結されている。フレックスジョイント１７４は、回転部１７０によって第一の部分１７２ａが略直線状に動いたときに屈曲するように非常に厚みが薄く形成されている。第一の部分１７２ａは、前記フレキシャの基部１８０にフレックスジョイント１７８を介して連結されている。そして、第一の部分１７２ａは、角度部の第二の部分１７２ｂにフレックスジョイント１８２を介して連結されている。また、第二の部分１７２ｂは、その他端部でフレックスジョイント１８４を介して前記フレキシャの収容部１

６２に連結されている。

【００６５】

第一の部分１７２ａ及び第二の部分１７２ｂを含む角度部１７１は、矢印１７６で示されるｘ軸に沿って直線状に動く。実際に、部分１７２ａ及び１７２ｂは略直線状にのみ動く。フレキシャが、その原位置（レスト位置）にあるとき、部分１７２ａ及び１７２ｂは、図示するように長手方向に角度が付けられていることが好ましい。これにより、回転部材１７０によって、矢印１７６で示すいずれかの方向に角度部１７１が押されるか又は引かれる。

【００６６】

アクチュエータ１５５は、回転部１７０を駆動しているとき、ハイバンド幅の作動と、パルスと振動の高周波の出力を可能としながら、その回転範囲の一部分の中で作動するのみである。フレックスジョイント１９２が、収容部１６２と基部１８０との間の屈曲部に設けられている。フレックスジョイント１９２は、収容部１６２（アクチュエータ１５５、回転部１７０、第二の部分１７２ｂも同様に）が、部分１７２ａ及び部分１７２ｂの動きに合わせてｚ軸に略直線状に沿って動けるようにする。フレックスジョイント１９０がｚ方向により容易に動くようにフレックスジョイント１９２の周りに屈曲自在とすべく角度部１７１の第一の部分１７２ａに設けられている。

【００６７】

アクチュエータシャフト１６４の回転方向を迅速に変更することによって、前記アクチュエータ／収容部は、前記ｚ軸に沿って振動させることができ、質量体として作用するアクチュエータ１５５によってハウジング上に振動を生成させる。加えて、フレキシャ１６０に設けられているフレックスジョイント１９２等のフレックスジョイントは、アクチュエータ１５５及び収容部１７２の原位置（レスト位置）に向けて復元力を与えるバネ部材として作用する。ある形態では、停止部をフレキシャ１６０に設けることにより、収容部１２２及びアクチュエータ１５５の動きを制限することができる。

【００６８】

他の形態では、その他の種類のアクチュエータアセンブリ、例えば、アクチュエータ自体に代わって、別体化された質量体を動かすフレキシャを設けることで、慣性触感を与えることができる。或いは、アクチュエータの回転シャフトに連結された偏心質量体は、前記ハウジングに回転慣性触感覚を与えるべく振動させることができる。該偏心質量体は、一方向又は二方向に駆動することができる。その他の種類のアクチュエータアセンブリ、例えば、リニアボイスコイルアクチュエータ、ソレノイド、可動磁石アクチュエータ等もまた使用することができる。

【００６９】

一の形態においては、上述したようなアクチュエータアセンブリは、ラップトップコンピュータのハウジング又はその他の装置のハウジングの任意の部位に連結することができ、そして、離隔して取り付けられたアクチュエータモジュールによって各製品のハウジングを通して振動を伝送しながら、ハウジングの一部を振動させるべく使用することができる。アクチュエータアセンブリは、前記質量体が振動させられるときに慣性触感フィードバックを与えるべく、ラップトップコンピュータのハウジング又は構成部品の異なる領域に取り付けることができる。

【００７０】

ユーザの体験は、ラップトップコンピュータ上のアクチュエータアセンブリの正確な位置及び出力される触覚効果に依存して変化する場合がある。アクチュエータアセンブリの連結のための場所は、ハウジングの底面、側面、又は前面、装置の操作時にユーザの手のひらに占有される面、タッチパッド又はタッチスクリーンに近接又は連結された領域を含む。効果的な場所はタッチパッド自体（例えば、タッチパッドの底面にアクチュエータアセンブリを連結する）である。ある形態では、タッチパッドが四辺形である場合は、より良好なコンプライアンスがタッチパッドの長軸に沿って得られるようになる。

【００７１】

一般に、感触は、ラップトップコンピュータ上にアクチュエータアセンブリを配置することによって限界周波数領域を越えてユーザに感知される。例えば、振動を伝達するのに最も効果的となる特定の場所は、実験により決定される。

【００７２】

多くの場合においては、数種類の触感効果の出力は、ユーザにとってぼんやり且つ濁ったように感じられる。そして、高周波数が支配的な効果は、より容易に感知される。本形態のための効果的な触覚効果の一つは、比較的に高周波数の「共鳴」効果である。ラップトップコンピュータのケース及びタッチパッドにおける共鳴振動は、これら振動を増幅することができる。ある仮想的な周波数において共鳴するように設計されたアクチュエータは、振幅変調技術によって広い周波数帯域を与えるために使用することができる。例えば、強制的に発生する２５Ｈｚの方形波は、大型の圧電セラミック振動子（図８ａ－８ｂ参照）等の同調共振アクチュエータによって生成される２５０Ｈｚの固有振動数を変調することで生成し得る。このような変調の仕組みは、存在する環境に同調させたアクチュエータ及び駆動すべき対象物に依存し得る。ある形態では、ある種の振動絶縁システムは、該エネルギーをラップトップコンピュータ又はその他の装置のその他の部分において、共鳴モードに分散させることとは対照的に、触感モジュールに限定されたエネルギーを維持するために使用され得る。

【００７３】

図６は、別の形態の斜視図である。ここでは、タッチパッドモジュールは、規格化された支持構造中に吊設され、高調波源に接続されており、そして、Ｚ軸に沿って振動し得る。本例では、タッチパッド２００は、該タッチパッドの面をＺ軸に沿ってタッチパッドの面に垂直に動かすアクチュエータアセンブリ２０２と共に動くことができる。前記タッチパッドは、一以上のレイヤー又は発泡材、ゴム、その他の適合した支持体によってラップトップコンピュータのハウジング２０４に連結され得る。ここでは、発泡材のストリップ２０６が、図６に示すようにタッチパッド２００とハウジング２０４との間のタッチパッドの周囲に設けられている。アクチュエータアセンブリ２０２は、タッチパッドアセンブリの底面（又はその他の場所）に連結され得るものであり、それにより、質量体が振動するときに、該振動がタッチパッドに伝わり、該タッチパッドがラップトップコンピュータのハウジング２０４に対してＺ軸方向に動く。例えば、アクチュエータアセンブリは、タッチパッドＰＣＢの底面に対して直接接着され得る。タッチパッドにおける浮動するアセンブリ及び表縁（タッチパッドを囲む面）は、Ｚ軸に沿って動くタッチパッドモジュールを単に動かすのとは対照的に、その代わりに動くことができる。

【００７４】

別の形態においては、スタンドアロン型のタッチパッドを使用することができ、ここでは、タッチパッドは、別体のハウジングに包囲され、ラップトップコンピュータ又はその他の装置とワイヤ又は伝動装置を介して通信できるようになっている。一の形態においては、該スタンドアロン型のタッチパッドは、手のひらパッド（又はその他の部材）に配置され、アクチュエータアセンブリが該パッドに連結され得るものである。アクチュエータアセンブリの質量体が振動するとき、慣性感覚は、これら部材を通してタッチパッドに伝達される。例えば、これは効果的にアクチュエータアセンブリからタッチパッドの面への慣性による連結を与える。発泡材のレイヤー（又はその他の柔軟材のレイヤー）は、パッドと地表との間に連結し得るものとなり、該パッドとタッチパッドを慣性的に動かし得るものとなる。この形態は、アクチュエータアセンブリが、前記一体化されたタッチパッドの近傍又はその上でラップトップコンピュータに取り付けられている形態よりもより強制的な感覚を与える。これはおそらく、より強く触感を出力し得る発泡材のコンプライアンスによるものと思われる。

【００７５】

タッチパッド全体は、一単位の部材として触覚を与えるものとなる。又は、他の形態においては、該パッドの独立して動く部分は、それぞれ触感フィードバックアクチュエータ自体及び関連する伝達装置となり、触覚が、特定される部位のみに与えられ得るものとなる

。例えば、ある形態は、タッチパッドのその他の部位に対して屈曲するか又はそれ以外の場合は可動の異なる部位を有するタッチパッドを備え得るものとなる。

【００７６】

別の形態においては、前記タッチパッドの周囲又は近接した面は、調和振動源（例、アクチュエータアセンブリ）に連結されており、一以上の軸上で動く。例えば、手のひら載置面は前記ラップトップコンピュータのハウジングに収納された慣性アクチュエータアセンブリによって駆動され得るものとなる。図７は、慣性駆動される手のひら載置面の一例の斜視図である。ラップトップコンピュータ２１０は、一般的なタッチパッドのように機能するタッチパッド２１２を備える。手のひら載置面２１４は、タッチパッド２１２に近接して配置されており、そこでは、手のひら載置面２１４は、弾性のある発泡材又はその他の適合したレイヤー上で、前記ラップトップコンピュータのハウジングに取り付けられている。ある形態では、面２１４は、ユーザを面により強く接触させるために凹部及び／又は凸部からなる手触り感を設け得る。図示する形態では、アクチュエータアセンブリ２１６が手のひら載置面２１４に接続されているので、アセンブリ２１６は、面２１４の裏面に連結されている。該アセンブリは、上記したいずれのアクチュエータアセンブリにもなり得る。例えば、アクチュエータアセンブリ２１６は、手のひら載置面２１４にｚ軸の振動を与え得るものとなる。

【００７７】

ユーザは、好ましくは、指先でタッチパッド２１２に触れている間に手のひら載置面２１４上に手のひら及び／又は数本の指を載置することが良い。それにより、ユーザは、タッチパッドを操作中に該手のひら載置面を通して触感を感じることができる。或いは、ユーザの一の手が指示（ポインティング）及びタッチパッドの操作に使用され、他の手が手のひら載置面２１４上に置かれて触感フィードバックを検知することが好ましい。前記手のひら載置面は、実際には接触の避けられない面として提供され、その結果、ユーザは、タッチパッドを操作しているときに数多く生じる触感イベントを体感し損なうことがない。ある形態では、いくら強くユーザが手のひらによって面を押しても、有用な帯域幅上で感知される強度の範囲では微妙な相違を生じ得るのみである。そして、その結果、使用された特定の装置の剛性及び質量が感知される。手のひら載置面がハウジングと連結される剛性は、異なる形態においては、特別な感覚のために調整され得るものとなる。

【００７８】

関連する形態においては、アクチュエータアセンブリは、異なる領域内に取り付けられ得るものとなる。例えば、アクチュエータアセンブリは、弾性のある開放発泡材又はその他の弾性材で形成されたレイヤーの上に取り付けられている手触りのある材料で形成された手のひら載置面の拡張部の底面に取り付けられている。

【００７９】

他の形態においては、手のひら載置面は、以下に説明するタッチパッドの移動と同様に、Ｘ及び／又はＹ方向に沿って移動し得る。慣性アクチュエータアセンブリは、移動を強要するのに使用し得るものとなる。又は、異なる種のアクチュエータ、例えば、移動モードにおいて意図しない強烈な停止による限界ひずみ等が生じないようにするための高度のアクチュエータとして認められているもの、及び相当に高い剛性である。移動する手のひら面は、アセンブリが、前記ラップトップコンピュータのハウジングに組み込まれるために平面状のアクチュエータに好適になり得るものである。平面状のアクチュエータについては以下に説明する。

【００８０】

図８ａは、本発明の慣性触感フィードバック装置の別の形態に使用できるアクチュエータの斜視図である。この形態においては、より高周波の機械的振動装置であって、タッチパッドに機械的に連結されているものが変調される。かかる実施の一例には、市販の大径薄型圧電変換器２３０、例えば、直径が６０ｍｍであって周辺で支持されたときの固有振動数が３００～４００Ｈｚのものを含む。該圧電変換器は、好ましくは、金属２３１の薄いダイヤフラム（シート）を含むことが良い。一の形態は、質量体及び振動する質量体から

より強い慣性触感覚を得るべく質量体を加え、固有振動を下げるために、前記圧電ダイヤフラムのセラミック部の中心において補助荷重２３２を有する。圧電変換器２３０の外周辺は（他の装置に）取り付けることができ、前記荷重２３２は、円盤の面に対して普通に振動し得る。これにより、前記変換器が接触しているハウジングに慣性触感が生成される。

【００８１】

アクチュエータ２３０は、触れている手又はラップトップの一部に触感を伝送する比較的高い周波数において動く調和振動子として機能する。振幅変調（エンベロープ制御）は、単一の基本的な情報モードよりもむしろ、より広い触感周波数帯を生成するために使用される。大径の圧電駆動装置、例えば、台湾のKingstateのものを使用することができる。異なるサイズの円盤もまた使用することができる。

【００８２】

望ましい触感覚を与えるため、大きな圧電変換器又は「ブザー」は、質量の、持続可能な移転（加速）を与えるべきであり、搬送周波数（それが振動する周波数）は、触感信号に従って変調されるべきである。ある種の電子機器が、この種のアクチュエータを作動するときにのみ必要となり得る。高電位供給装置は５ボルトから生成できる。振動回路、例えば、自励型のものは、該素子を駆動することができる。該振動、並びに前記出力の強度の変調を行うための比例制御を開始、停止するために開閉機能を付与し得る。

【００８３】

図８ｂは、触感を与える圧電変換器の別の形態２３４を示す側面図である。ここでは、該変換器は、タッチパッド（又はタッチスクリーン）に対してｚ軸に沿って直接（非慣性の）振動を与える。ラップトップコンピュータ又はその他の装置のハウジング２３６は、タッチパッドの部材２３８を被うベゼル（表縁）を含み得るものであり、それにユーザが物理的に接触することでコンピュータ又はプロセッサに入力される。タッチパッド部材２３８は、タッチパッドとその他の電子機器とのインターフェイスをとるために、必要な電子部品を備え得るものである。タッチパッド部材２３８は、効果的な触感出力を可能とすべく選択された特定された質量を有するスペーサ２４０上に配置し得るものである。スペーサ２４０は、圧電変換器の一部である圧電金属ダイヤグラム２３１の周縁に配置されており、また、そこでは、電子リード２４１がダイヤフラム２３１と信号源２４６との間に接続されている。圧電セラミック部材２４２は、圧電変換器の一部でもあり、金属ダイヤフラム２３１に連結され、電子リード２４３は、前記部材２４２と信号源２４６との間に接続されている。導電性の電極が、セラミック部材２４２上に配置されている。接触パッド２４８が、前記部材２４２とハウジング底部２５０との間に配設されており、そこでは、該接触パッドは、セラミック部材２４２及びハウジング底部２５０の両者に強固に連結されている。接触パッド２４８は、小型に作られており、それにより、ダイヤフラム２３１の撓みが増加し、より強い加速を得てより強い触感効果をもたらす。ハウジング底部２５０は、例えば、プリント回路基板（ＰＣＢ）を備え得るものである。一以上の予め設けられたバネ部材２５２、例えば、重ね板バネ、つる巻きバネ等によって、タッチパッド部材２３８がハウジング底部２５０に連結されている。

【００８４】

作動時においては、圧電変換器は、信号源２４６から振動電流がダイヤフラム２３１及びセラミック部材２４２を通って流れているときにｚ軸に沿って動く。このため、スペーサ２４０は、ダイヤフラム２３１の周縁にのみ設けられ、これにより、ダイヤフラムの内部及びセラミック部材２４２の動きが可能となり、セラミック部材によってハウジング底部２５０が押圧され、その結果、前記ダイヤフラム２３１によってスペーサ２４０が押圧される。そして、該スペーサ２４０によってタッチパッド部材２３８が押圧される。これは、タッチパッド部材を持ち上げるように押圧し、バネ部材２５２は、タッチパッドにその中立位置に戻るようにバネ復元力を与える。該圧電変換器が、その反対方向に同様に動くとき、振動する信号によって駆動され、これはタッチパッド部材２３８をハウジング底部２５０に向けて下方に動かす。前記タッチパッド部材は、このようにｚ軸に沿って振動す

ることで、該タッチパッド部材に触れているユーザに触感を与えるのである。

【００８５】

ある形態では、タッチパッド形態２３４の構成部品は、より効果的な触感を与えるために選択される。例えば、圧電変換器が機構システム（圧電変換器自体を含む）の固有振動数に近い状態で振動する場合、より強い力及びより効果的な触感が出力され得る。可動の機構システムの固有振動数は、以下のようにｋ１とｋ２との和をｍによって除した値の平方根で略表され得る。

ｆｎ≒√（ｋ１＋ｋ２／ｍ）

ここで、ｆｎは固有振動数、ｋ１は圧電変換器の金属ダイヤフラム２３１のバネ定数、ｋ２はバネ部材２５２のバネ定数、そして、ｍはスペーサ２４０、タッチパッド２３８及び該タッチパッドに取り付けられているサスペンションの各部分の総質量である。この質量、ならびにバネ定数は、望ましい低い固有振動数、例えば、約１２０Ｈｚ以下を実現するために選択し得るものであり、これにより、効果的な触感がもたらされる傾向がある。スペーサ２４０は、複数の圧電変換器、例えば、並行して位置するものを、ハウジング底部２５０に対向して位置させ得る。これにより、該複数の変換器は、より強い触感効果のために調和して駆動され得るものとなるか、又は異なる時間において、タッチパッド部材２３８の特定される位置において触感を与えるものとなる。

【００８６】

駆動信号を与える一つの方法は、固有振動数ｆｎ又はその近傍の振動数において開始振動搬送信号を与えることであり、この搬送信号を効果エンベロープによって変調し、該当する場合（例えば、望ましい周波数又は効果を与えるための望ましい構成のために振幅を形成する場合）、その変調された信号によって増幅器を駆動し、次には、それは圧電変換器を駆動するのである。サイン波の搬送信号は、方形波又はその他の種類のものと対照的に、図８ｂで説明される形態において静かな触感を与える傾向にあり、これはしばしば、より望ましいものである。

【００８７】

その代わりの形態においては、圧電変換器及びスペーサは、方向を変え得るものであり、それによりスペーサ２４０がハウジング底部２５０に接触し、ダイヤフラム２３１がスペーサ２４０上に載置され、セラミック部材２４２がダイヤフラムの上に配置され、セラミック部材が、駆動信号によって振動させられたときにタッチパッド部材２３８又は該タッチパッド部材に連結されたパッドに直接衝撃を与える。更に他の形態においては、セラミック部材は、タッチパッド部材に直接連結され得るが、この場合、一般に力が弱まり、より効果の小さい触感効果がもたらされる。

【００８８】

面移動の形態

これらの形態はユーザに触感を与えるために該ユーザに接触する面を移動させるものである。ユーザは、皮膚が剥ぎ取られる感覚で、迅速な感覚が形成されながら面が移動する感覚を覚える。この種の触感フィードバックは、固定された面とインターアクションすることなく、平面上の面の動き、又は、ユーザの指又は手に接触した近接した各面の間の相対的な動きのいずれかに基づいている。タッチパッドモジュールの面に接触しているか又は近接している面の両者の移動（図９～１２）、並びにタッチパッドの面自体（図１３～１４）を移動させる動作は、以下の形態で説明される。同様にアクチュエータは、いずれかの形態（図１５～１７）に使用される。米国特許５，１８４，８６８号に記載された移動する面の発明もまた適用することができる。

【００８９】

近接した各面間における小さな（＜１ｍｍ）移動量は、指の組織に良好な信号を伝送する。強調された面は、物理的な面のざらつき（凹み、粗さ等）を有しており、任意の位置又は方向に向かうようにユーザを拘束すべく形成され得るものである。ある形態では、小さな横方向の移動（０．２５ｍｍ～０．５ｍｍの間の指先における移動量）は、遠隔慣性振動、又は、タッチパッドの直下の平面から逸脱した（ｚ軸の）振動よりさえもより効果的

なものとなり得る。例えば、慣性結合は、ある形態では、より離間した、接続を絶たれた感覚を有し得るものである。

【００９０】

別体化された面の移動

タッチパッドモジュールの最上層に位置する別体の面を移動させることは、良い相関を示すフィードバックを与えるに当たり非常に効果的である。このフィードバックからは、ＰＤＡ装置又はタッチスクリーンにおける如く、綺麗な面が画像表示部上で移動されるような十分に同期された感覚が得られる。その他の面を側部に移動させること又はタッチパッドに近接させることは、他の形態において実行される。

【００９１】

図９は、別体化された面の第一の移動形態２５０の斜視図である。ここでは、タッチパッドモジュールと滑り接触している別体化された薄い面が指の下で横に動いている。移動する面（「面」）２５２がタッチパッド２５４の最上層にあって固定されたタッチパッド２５４を被っている。拡張部材２５６ａ及び２５６ｂが移動面２５２に連結され、タッチパッド２５４から離れてｘ及びｙ方向に略垂直に拡張され得るようになっている。アクチュエータ２５８ａ及び２５８ｂが各々対応する拡張部材２５６ａ及び２５６ｂにそれぞれ結合されている。この説明される形態においては、アクチュエータ２５８は、関連する拡張部材２５６上に直線の力を出力するリニアアクチュエータであり、それにより出力される力の方向に前記移動面を移動させるのである。例えば、アクチュエータは、「Ｅ」コアアクチュエータになり得るものである。二つの棒状の磁石２５９は、強磁性体３８２の下のコイル２６０を露出させるために、アクチュエータ２５８ｂ上への図示を省略する。

【００９２】

滑り面２５２は、剛性があるか又は実質的に剛性のある材料のいずれかで形成し得るものであり、例えば、カプトン（ピラミッド）のフレキシブルプリント回路基板材料が使用し得る。前記拡張部材２５６には、座屈防止のために補強部材を組み込み得る。滑り面２５２は、ユーザの皮膚組織と該面とを互いに接触させるため摩擦力を与えるざらつきのある面とし得る。移動面２５２の最上層における領域は、手触りが粗い感覚を皮膚に覚えさせることなく十分な面粗度を有する手触りを備えるものとし得る。移動面の裏面に、面２５２とタッチパッド２５４との間の滑り移動を促進させるべく摩擦の小さなコーティングを施し得る。この裏面の構成部品は、相当に薄くし得るものであり、例えば、０．０１０インチ（０．２５ｍｍ）未満の厚さである。

【００９３】

ユーザは、移動面２５２がタッチパッド２５４自体であるかの如く該移動面２５２を指し示して接触をする。面２５２は、十分に薄く形成されることで、まるでユーザが面２５２上で触れている位置の直下のタッチパッドに触れているかの如く、タッチパッド２５４により面２５２へのユーザの全ての接触が検出し得るようになっている。

【００９４】

ある形態では、各アクチュエータは、移動面から比較的遠く（例えば、＞１０ｍｍ）に配置され得るものとなり、これらの場合においては、より剛性のある拡張部材２５６は、できる限り小さな摩擦で、且つ面外の運動によって張力及び圧縮を伝送する。例えば、ガラス又はカーボンの繊維積層体によれば、この機能を実現し得る。

【００９５】

いくつかの可動磁石アクチュエータの形態においては、薄い希土類磁石片を、移動面２５２に可動磁石の機能を果たさせるべく積層することができる。例えば、可動磁石片が厚さ＜１ｍｍのオーダーであり、「Ｅ」コア及びコイルが拡張部材２５６の末端部分の下部に位置している場合、具体的には、タッチパッドＰＣＢ自体に直接取り付けられている場合、高いレベルの調和が実現される。該コイルの線材は、タッチパッドＰＣＢ自体に半田付けすることができる。

【００９６】

図１０は、別の移動面の形態２７０の平面図であり、そこでは別体化された可動の触覚面

が上方に位置し、タッチパッドに滑りながら接触している。その面は、高帯域幅アクチュエータによって、高忠実な機械連結を通して、タッチパッドに対して移動する。

【００９７】

この形態においては、移動面２７２が、図９に示す形態と同様に、タッチパッド２７４の上部に位置する。拡張部材２７６が回転アクチュエータ２７８に向けた方向（ここでは、ｘ方向）に突き出ており、これは、本例ではラップトップコンピュータのハウジング２８０に取り付けられている。アクチュエータ２７８は、順に拡張部材２７６に連結される連結部材２８４に連結された回転シャフト２８２を有するＤＣ回転モータになり得る。例えば、上述したアクチュエータアセンブリ１５０の連結部の一部を使用することができる。アクチュエータ２７８が、いずれかの方向にシャフト２８２を回転させるとき、前記連結部は、面２７２への前記回転を対応する方向（右又は左）への移動に変換する。例えば、約＋／－１ｍｍの移動量が実現される。ユーザは、面２７２上で指を動かすときに面の移動を感じる。モータの回転は、Ｘ軸における大変に綺麗で高忠実な移動をもたらす結果となる。ＤＣモータの配置設計は、ラップトップコンピュータにおいて、エンクロージャ又はハウジングの側面又は正面に予備的に設けられた空間内で行われる。同様な拡張部材、連結部材及びモータを、面２７２を動かす方向であるｙ方向に設けることができる。ユーザの入力は、動く触覚面を通してタッチパッド上で検出される。

【００９８】

前記薄い面は、タッチパッドの領域の内側に適合するべく、周囲全体の小さな縁によって形が整えられ得る。四辺形の拡張部材が、アクチュエータによって駆動されるかなり剛性の高いストリップ（細長い片）を形成するべく大きな薄板に切り出され得る。このストリップは、アクチュエータが作動により該ストリップを押すときにストリップが座屈することないように十分に面積が大きいことが要求される。

【００９９】

図９に示す形態のように、平滑な面を、タッチパッドに接触して、ユーザの指が通常触れる該タッチパッドのプラスチックの被いと摩擦の小さい平滑な滑り相互作用を与えるように、面２７２の裏面に設け得る。移動面の表面側は、ユーザに良好に把持されるように、例えば、ざらざらしたサンドペーパーのような摩擦を持たせることができる。これは、非常に良好なタッチ面を与えることができる。その理由は、それは指の表面と何らかの機械的接触を生じるからであるが、触れたときに粗く感じられる程には粗いものであってはならない。他の形態は、多種の摩擦面を適用することができる。他の形態は、より平たいアクチュエータ、例えば、可動磁石アクチュエータ又はボイスコイルアクチュエータを使用することができる。

【０１００】

プラスチック又はその他の材料製の二つのストリップ２８６を、タッチパッド（例えば、タッチパッドに向けて開口したハウジングの周縁）を囲むように、しかも、移動面２７２を拘束してそれをタッチパッド２７４に対向し且つ並行な平面状態を維持するべく面２７２の端部を被うように、前記周縁に取り付けることができる。

【０１０１】

図９及び図１０に示す形態は、強制的な触感を与えることができる。タッチパッド上に面を付加するにあたり、タッチパッドのセンサ作用を実質的に妨げるものであってはならない。ユーザは、固定されたタッチパッドに対する面の相対移動を通して、指示及び触感フィードバックの受容を同時に行うことができる。タッチパッド上で移動している面を指で触れて移動させる際にラップトップコンピュータ又はその他の電子機器に入力を与えることはユーザにとって容易である。ある形態では、移動面は、密着して接触させることなく、上方で保持することができ、タッチパッドへのユーザによるある程度の圧縮が、無制限に作動させ、センサアレイに接近させるために必要となる。

【０１０２】

表示されたスクロールバー上、及び、ラップトップコンピュータによって表示されたデスクトップＧＵＩ上の周囲にカーソルを動かすとき、ユーザは、明らかな、カーソルと空間

的に良い相関関係にある高忠実再生を感じる。その相関性の性質は、ユーザがｘ又はｙ軸のいずれかに指又は物体を動かすことによって異なったものとなり得る。図示する形態２７０におけるアクチュエータは、ｘ軸に面２７２を動かす。その結果、前記カーソルをアイコン上に上方又は下方へ動かし、ユーザは、面２７２がカーソルの動きに対して垂直であるときの動きに集中しないか又は該動きを観察しない場合、同じ方向に突然の飛び出し（ポップス）又は同様な触覚効果を覚える。

【０１０３】

移動方向におけるユーザの動き（図１０の例におけるｘ軸）は、さらに強制的な傾向がある。例えば、ユーザが、一の表示された比率ボタンから次へカーソルを動かすためにｘ方向に指をドラッグすることによって、面２７２は、ユーザを次のボタンに誘導し、面の動きが大変小さく生成しているにも拘わらず、移動を阻止される感覚を感じ得る。動きの方向に対抗する面移動力は、効果的となり得る。例えば、ユーザがアイコン上に左に動かすとき、右方向に向かう移動力は、さわやかで自然に感じられる。触感フィードバックが一の軸においてのみ可能である場合、ｙ軸は、ある形態では、より良好な選択となる。その理由は、ＧＵＩデスクトップ及びアプリケーション上においては、より垂直方向に移動させられる内容があると考えられるからである。

【０１０４】

短く、明瞭なパルスは、一の物体から他の物体、例えば、各画像ボタンに亘ってカーソルを動かすときに優れた変化を与え得るものとなる。振動は、面移動形態におけるユーザに、面を駆動するアクチュエータ、例えば、サイン波又はその他の周期的波によって振動させることによって伝達され得る。そして、それにより、反対方向に移動面を振動させるのである。

【０１０５】

ユーザはまた、カーソルを制御する動きの間にタッチパッドから自然に指を離し勝ちである。そして、モータ及び連結部材における中央に付勢させる固有のバネ力は、次のインタラクションに備えて、移動面２５２又は２７２を中立（元の）位置に復帰させ得るものとなる。制御されたカーソルは、フィードバック装置が、中立の原点位置に引き返す間、動かない。その理由は、タッチパッド上の面のみが動き、ユーザの指の如くコンピュータに対してタッチパッドを通して入力を与えないからである。

【０１０６】

特定される方向における動きは、面の移動の形態を、ある形態において、局所的な擬似運動感覚のフィードバックを伴った相対的な指示装置のように振舞うことを可能とする。触覚フィードバックは、このような形態において与えられる触感フィードバックの依然として基本的な類型であるが、面の小さな移動量は、喩え、それらが突然の飛び出し（ポップス）に過ぎなくとも、ユーザの指をある方向に押し進める規制用「傾斜」のように感じられるように作用する駆動バネ力として劇的に感知し得る。

【０１０７】

アクチュエータの全体的な剛性は、結果に影響を与える。ユーザが移動面を強く押し過ぎた場合、ユーザは、指でドラッグ／指し示している間、面を動かすことで、アクチュエータをそのバネ中心から逸脱させ得る。より好ましい形態では、力強いが剛性の高いアクチュエータを有しており、ユーザは、強く押すことによっては、殆ど逆向きに駆動させることがない。

【０１０８】

移動面上に特定される移動量又はコンプライアンス量、例えば、約２ｍｍを有することは、ある形態では、望ましいものである。ここでは、モータ及び連結部材から強い中央へのバネ付勢力が存在しており、二つの物体の間、例えば、ＧＵＩにおける各ボタン間でカーソルを動かすことが大変現実的となり得る。その理由は、ユーザは、指の圧力が減少するまで真の運動感覚的なフォースフィードバックを感知し、その指は、相対モードにおいて、スクリーンを素早く横断するからである。出力される触感効果は、シンプルな触覚のポップスであり、実際の運動感覚的なバネは、Ｘ又はＹ方向に力を与えることがないのであ

る。しかしながら、ユーザは、その指が近接した物体、例えば、次のボタンに引っ張られることを検知するのである。

【０１０９】

運動感覚的なフォースフィードバックが異なる形態においては可能であることは特筆すべきである。例えば、ユーザが、その指を移動面上の一の場所に保持し、移動面が移動のために十分に広いとき、力は、移動面が動く方向の自由度に出力され、運動感覚のフォースフィードバックを与え得るものとなる。タッチパッドのセンサは、力、例えば、バネの原位置から動いた距離に依存する強度を有するバネ力を計算することによって指／移動面の位置を示すセンサとして使用し得るものである。これにより、そのような形態は、触覚及び運動感覚の両者を兼備する両用モードとなり得るのである。

【０１１０】

移動面のある形態は、他の形態が滑りが小さく、大変剛直なものであり得るのに対して、ユーザによる滑り移動を可能とする。多くの形態においては、面の最大許容移動量が二つの近接した画像ターゲットの間で横移動を可能とするのに十分である場合、運動感覚モードは、効果的となり得、ユーザは、面上で動いているのに気づかない場合があるのである。ある形態は、二軸（Ｘ及びＹ）における移動及び力を与え、タッチパッドの全ての方向において、運動感覚的に駆動されたフィードバック（実際のバネ）を可能とする。

【０１１１】

触感効果は、ユーザがタッチパッド上で指又は物体を動かしていないときには同様には感じられない。しばしば、触感効果（移動止めポップ効果）を伴ったタッチパッドの動きに対応した内容及び値がある。例えば、これは、ユーザの指が動き、該指が各アイコン又は各ボタンの間を前記移動する面を転移点まで移動する際にポップ効果を受け取るときに効果的である。

【０１１２】

別体化された移動面のための上記した有利な点のうちの多くは、タッチパッドの面を移動させることにも適用できる。以下に詳述する。

【０１１３】

図１１は、別体化された移動面及び可動コイルの別の形態２９０を示す斜視図である。この形態においては、フレーム２９２が装置のタッチパッド２９４の上部に位置している。フレーム２９２は、タッチパッド２９４の直上に位置する面部分２９６を含み、それは、部分２９６へのユーザの接触が下部のタッチパッド２９４によって検出されるように十分に薄いものである。フレーム２９２は、ボイスコイルアクチュエータ３００の一部である統合された音声コイル２９８も備える。コイル２９８は、フレーム２９２に成形により埋入された巻き線であっても良く、それはＰＣＢであっても良い。アクチュエータ３００のその他の部分は、コイル２９８の上部に配置された静止した２本の棒状磁石を備え、ラップトップコンピュータのハウジングに取り付けられている。また、支持板３０４は鉄製であり、フレーム２９２のその他の側面に配置され、前記ハウジングに取り付けられて磁束帰還路として使用されている。その鉄製のサブアセンブリは、例えば、ＰＣＢ自体に取り付けることができる。

【０１１４】

この状態で、磁石３０２の磁場と、コイル２９８を通って流れる電流とは、相互作用し、フレーム２９２上に直線の力を生じさせる、それは、該フレーム及び部分２９６を矢印３０６で示されるように動かす。これは、上述した別体化された移動面の形態と同様にして、ユーザに触感を与える。前記ハウジングは、フレーム２９２の部分２９６を包囲する開口部以外の全てのフレームを被い得る。ある形態では、コイル２９８の各線材は、可動フレーム２９２から分岐した別体の分岐回路を使用してタッチパッドＰＣＢに連結し得るものとなる。

【０１１５】

図１２は、別体化された移動面の別の形態の斜視図である。本形態においては、タッチパッドを包囲する面は、タッチパッドの面に対してｘ及び／又はｙ方向に移動する。親指用

面３１２は、タッチパッド３１４の下側部に位置しており、連結部材２９５に強固に連結されている。連結部材３１６は、柔軟性連結部材３１８に連結されており、それは、ラップトップコンピュータのハウジングに取り付けられているアクチュエータ３２０の回転可能なシャフトに連結されている。アクチュエータ３２０がシャフトを回転させたとき、柔軟性連結部材３１８は、矢印３２２によって示されるように、直線状に連結部材３１６を動かす。それは、親指用面３１２をｘ軸に沿って直線状に動かす。親指用面３１２は、面３１２の直下にある標準ボタン（図示せず）に滑り接触している状態が示されている。

【０１１６】

ユーザは、その親指、手のひら、又は指を、触感を感じるためにタッチパッドを操作している際に親指用面３１２上に載置することができる。親指用面３１２の下部に配置されたボタンを押すことで、ユーザは、面３１２をただ押し下げるのみとなる。総じて、その感覚は、上述したその他の移動面による感覚と類似した傾向にある。他の形態においては、連結部材３１６は、ラップトップコンピュータ又はその他の装置において、アクチュエータ３２０の望ましい移動量を可能とするためにずっと全長の長いものとなり得る。

【０１１７】

一つの欠点は、ユーザが親指用面３１２上に親指、指、又は手のひらを置かない限りフィードバックが得られないことである。ユーザは、タイプするためにその他のボタンに触れなければならないであろうし、それによって触感体験を失うことになる。より大きな面３１２又は手のひら拡張パッドは、同じ手でタッチパッドを指し示す場合にユーザが親指を面３１２上に保持することが困難な形態で使用し得るものとなる。

【０１１８】

タッチ装置の移動

これらの形態は、別体化された面ではなく、タッチパッド（又はタッチスクリーン）の面自体を移動させる。ユーザは、横方向にタッチパッドが移動し、その皮膚が剥ぎ取られる感覚を覚えることで、迅速に触感が生成される様を体感する。タッチパッドは、ラップトップコンピュータのハウジング等の固定された周縁部に対して動かされ得る。

【０１１９】

図１３は、タッチパッドの面を移動させる一の形態３３０の斜視図である。タッチパッド３３２は、アクチュエータ３３６によって、ラップトップコンピュータのハウジング又はＰＤＡハウジング等のハウジング３３４に対して動かされる。ここで説明する形態においては、アクチュエータ３３６は、ＤＣモータ等の回転アクチュエータであり、連結部材３４０に連結された回転シャフト３３８を有する。該連結部材３４０は、その他端部でブラケット３４２に連結されており、そこでは、ブラケット３４２は、タッチパッド３３２モジュールの裏面に連結されている。該連結部材は、接合部、及び／又は、柔軟性／コンプライアンスを有しており、それにより、シャフト３３８の回転運動をブラケット３４２上の直線の力に変換させ、結果として、矢印３４４で示されるようにタッチパッド３３２を横方向に動かす。例えば、該連結部材は、図５に示すアクチュエータアセンブリの連結部材と同様に、ポリプロピレンで形成し得るものである。ラップトップコンピュータのハウジングは、可動のタッチパッドモジュールのための拘束構造の役割を果たす。

【０１２０】

例えば、標準的なＤＣモータは、アクチュエータ３３６、及び連結部材３４０のためのポリプロピレン連結アセンブリのために使用され得る。一の形態においては、触感フィードバック構成部品は、オプションのディスクドライブ装置等のラップトップコンピュータ用のオプション構成部品が通常位置する場所に配置され得るものとなる。

【０１２１】

他の形態においては、アクチュエータ３３６は、タッチパッド３３２から離間して配置され得るものとなり、例えば、図１３に図示するようにタッチパッドの直下においてハウジング中で空いているスペースならどこにでも配置し得る。連結部材は、下の図１４に示すように、タッチパッドから離間してアクチュエータを配置するべく使用することができる。

【０１２２】
タッチパッド全体を、一又は二の軸上で移動させることは、総合的な触感のためには好ましいといえる。タッチパッドの非常に小さな移動量（０．２ｍｍ＜ｘ＜０．５ｍｍ）は、有効な触感を与えるために望ましい。実用上の強度範囲を加味して評価した本形態のためのパワーの消費量は、現状入手可能な慣性マウスインターフェイス装置の消費量より小さくし得る。それは、ＵＳＢのようなホストコンピュータへのインターフェイスを含めた全てに必要なパワーを受け取り得る。
【０１２３】
この種の形態においては、いくつかの優位点が明らかである。フィードバック感覚が、直接的であり、指示と相関性が高く、正確であることである。形態の実施が、柔軟で且つ控えめであること、そして、触感の構成部品の付加によってタッチパッドの使用法が変化しないことである。前記移動する面は、慣性による場合と比較してより小さな移動量が必要とされる。－これにより、少ない消費パワー及び製造上の利点が実現される。ある形態では、タッチパッドの動きは、ｘ－ｙ平面上の角度に方向付けされる。欠点としては、比較的大きなＤＣモータを使用すること、柔軟な連結部材が多くの逃げ空間を必要とし、摩擦を生じる場合があること、そしてパワーの消費が比較的大きいことである。
【０１２４】
図１４は、移動タッチパッドの別の形態３５０を説明する斜視図である。ここでは、Ｘ及びＹ方向の両方の方向に動き得る。タッチパッド３５１は、ポリプロピレン等の柔軟性部材３５４を介して第一の連結部材３５２に直接連結された回転シャフトに連結されている。アクチュエータ３５３は、ラップトップコンピュータのハウジングに取り付けられている。アクチュエータ３５３のシャフトが回転するとき、柔軟性部材３５４が該回転運動を直線運動に変換し、ｘ方向に連結部材３５２を移動させる。それは、順に矢印３５５で示すようにタッチパッドを移動させる。前記第一の連結部材３５４の末端に、例えば柔軟な連結によって、第二の連結部材３５６が連結されている。
【０１２５】
第二のアクチュエータ３５８は、ラップトップコンピュータのハウジングに取り付けられ、柔軟性部材３５７によって前記第二の連結部材３５６の他の末端に連結されている。アクチュエータ３５８の回転シャフトによって出力される回転力は、柔軟性部材３５７によって直線の力に変換される。この直線の力は、第二の連結部材３５６をその長手方向に沿って直線状に動かすことになり、それは、順に第一の連結部材３５２をその略末端においてアクチュエータ３５３の近傍でｙ軸に沿って回転させる。そして、タッチパッド３５１をｙ軸にほぼ沿って動かす。アクチュエータ３５３及び３５８は、例えば、図１５～１７において以下説明するように、ＤＣモータ又はその他の種類のアクチュエータ（例えば、リニアアクチュエータも使用し得る）になり得るものである。これら連結部材は、任意の適当な材料、例えば、炭素繊維から形成し得るものである。好ましくは、その取り付け構造又は連結アセンブリにおける望ましくない変形によって吸収されるエネルギーが僅少であることが良い。
【０１２６】
このようにして、その機構は、ｘ及びｙの動きを干渉しないものとする。アクチュエータ３５３を作動させることによってｘ軸の動きが与えられ、アクチュエータ３５８を作動させることによってｙ-軸の動きが与えられる。ｘ及びｙ軸の両方の動きが、両方のモータを同時に作動させることによって与えられる。両方のアクチュエータは、純粋なＸ又はＹの動きを実現するため、連結部品を束縛することなく、協働して（通常モード）又は個別に（個別モード）、いずれかによって駆動され得る。更に、駆動の流れのいずれかの組み合わせによって、その結果として生じる力が、同様な忠実さをもって且つ束縛されることなく任意の軸に沿って生成される。
【０１２７】
一の形態においては迅速な評価及びＸ及びＹの力を出力するためにファームウエア（ＲＯＭに書き込まれたソフトウエア）、例えば、マイクロプロセッサ等の局所的な制御機器上

で実行されるか又はホストＣＰＵで実行されないソフトウエアを使用できる。ある形態では、そのようなファームウエアは複雑すぎるため、その代わりに、前記二つの主要なフィードバック軸の間の電気的な方法によるスイッチングを伴う機構を使用し得る。一の形態においては、前記二つのＤＣモータは、該二つのモータの内の一つを通して電流を逆に流すスイッチを有する直列回路に接続され得る。

【０１２８】

図１４に示す形態においては、ユーザは、タッチパッド上で指又は物体を動かすときにｘ及びｙ方向の力の間の相違を感じる場合がある。指／カーソルの動きと触感フィードバックの相関及び連携をとるに際して、触感の値が存在している。ある場合では、連携によって触感のＳ／Ｎ比が増幅され得るようになる。例えば、アイコン又はボタン上をカーソルを右から左に動かすことによって、フィードバックがｘ軸に沿って水平な方向に向いているとき、より良好な感覚を覚え、ユーザにとってより現実のボタンに近い感覚が感じられるようになる。無指向な状態又は調整不良を生じることなく、フィードバックがカーソルの方向と合っている場合、全体としてパワーがより少なくて済むようになる。ある場合では、より微弱な触感効果は、調整不要によるより強力な効果よりも重要なものとなり得る。

【０１２９】

強化された手触りを有するタッチパッドの面は、強化された手触りを有する固定された周囲の面に対応して動く。該強化された手触りは、より粗く、波形の、或いは、テクスチャード加工されたもので、ユーザによる強い接触を許容する。

【０１３０】

いくつかの他の形態においては、タッチパッドの面は、ｘ及びｙ方向に相互に関連して動く、互いにかみ合った面特性を備え得るのものとなる。例えば、タッチパッドを半分に分割した部分のそれぞれは、互いに対応して動くようにアクチュエータによって駆動し得るものとなる。

【０１３１】

他の形態においては、タッチパッド、タッチスクリーン、又はその他の装置をｚ方向に動かすために、その他のアクチュエータを使用し得る。例えば、圧電変換アクチュエータ、ボイスコイルアクチュエータ、可動磁石アクチュエータは、タッチ面を直接に動かすため、タッチパッド又はタッチスクリーンに直接に連結し得るものとなる。また、タッチパッドの面は、一定不変の触感面及び基準ピッチ面を備え得るものであり、ここでは、該基準ピッチ面は、ｚ軸に沿って前記一定不変の触感面に代用され得るものとなる。

【０１３２】

図１５ａ及び図１５ｂは、それぞれ、表面側及び底面側の斜視図であり、タッチパッドを移動させるのに使用される新規な「フラットＥ」アクチュエータ３６０の異なる形態である。図１５ｃは、アクチュエータ３６０の側面図である。アクチュエータ３６０は、非常に薄型に設計されており、このため、もともとタッチパッド、タッチスクリーン、又はその他の類似した装置の一部であり得た平面状のアセンブリ中にあって機能させるにあたりより適切なものとなり得る。「Ｅコア」アクチュエータの位相は、最小の磁化された材料を使用する優れたアクチュエータを提供するものであり、良好な力と帯域幅を提供するものである。可動磁石アクチュエータの欠点の一つは、大きな奥行きを必要とする点（「Ｅ」コア型の強磁性部品の幅は、アクチュエータの奥行き全体を減じることで、ある程度は高さに置き換え得る。）である。

【０１３３】

アクチュエータ３６０は、タッチパッドの移動（又は、その代わりに、図９～１４に示す形態の如く、別体化された面を動かすために）に使用し得る「Ｅ」コアの工夫に富んだ形態を呈示するものである。図１５ａ～１５ｂに示した、上方に折り重なった平面状の３-Ｄ形態、それは実質的に２-Ｄの場合のように作用し得るが、各棒状磁石におけるより大きな磁束の洩れ及び一様でない磁束を伴う可能性がある。

【０１３４】

アクチュエータ３６０は、「Ｅ」字状の強磁性体の部品３６２を備え、それは、鉄金属又は炭素鋼板等の金属により形成され得るもので、単体金属又は積層体になり得るものである。コイル３６４の線材が前記「Ｅ」字状の強磁性体の部品３６２の中央のポールの周囲に巻き付けられている。浮動性のプラスッチック製保持器３６８を強磁性部材３６２上に配置することができ、それは、前記保持器の開口に位置し、且つコイルが巻き付けられ貫通している軸に平行に該軸上を回転するように方向付けされている二又はそれ以上のローラ３７０を備え得る。該保持器は、例えば、他の構成部品に接触することなく、ローラを回転させるように、柔軟であり得て且つ浮動するものである。二本の棒状の磁石３６６は、強磁性部材３６２及び保持器３６８上に配置され、これにより、磁石と強磁性部材の間に空隙が形成されている。磁石３６６は、各ローラ３７０の上部でそれに接触した状態で配置されている鉄製の支持片３７２の裏面（他の方向でも良いが各指の方向に）に連結されている。このようにして、各ローラにおいて、磁石と強磁性部材３６２との間に呼び磁気ギャップが設定される。鉄製の支持片３７２は、図１５ｄに示すように、タッチパッド３７３に強固に連結され得るものであり、それにより、タッチパッド、鉄製の支持片３７２、及び磁石３６６が、強磁性部材３６２に対応して移動し得るようになる。例えば、磁石は、ある形態では、ネオジミウム製の基板に接着された二つのポールになり得るものであり、その鉄製の部品は、約１ｍｍ厚さの単一のシート材から型押しされてなり得るものである。補助ローラ又は発泡材が磁石３６６に対向した強磁性部材の末端を支持するために使用し得る。前記磁石、保持器、及び支持板は、その他のＥコアタイプのアクチュエータと同様、正面端部よりもむしろ「Ｅ」ポールの側部に配置されている。これにより、本発明のアクチュエータをラップトップコンピュータ及びその他の携帯応用装置用として大変薄型とすることが可能となる。

【０１３５】

作動時においては、コイル３６４を通って電流が流れ、それにより、磁束が前記強磁性部材を通って矢印３７４の方向に流れるようになる。作用時においては、鉄製の平板３７２は、矢印３７６で示す軸に沿った方向（この方向は、コイルにおける電流の方向に依存している）に動く。各ローラ３７０の回転により、鉄製の平板３７２及び磁石３６６が強磁性部材３６２に対して移動される。前記浮動性の保持器３６８により、各ローラが回転するときに該ローラの望まない方向への動きが阻止される。また、強磁性部材３６２及び磁石３６６との間で起こる通常の磁性引力は、前記複数のローラ３７０と協働する。その他のフラットＥに関する形態は、通常の磁性力に協働（からの動きを可能と）するフレキシャと刃形のサスペンションを備え得る。

【０１３６】

ここで説明されるフラットＥアクチュエータの形態は、タッチパッド（又はタッチスクリーン）又はタッチパッド上若しくはその側部において別体の面を移動するのに使用し得るものである。例えば、二つのフラットＥアクチュエータは、タッチパッド又は面を二つの軸、ｘ及びｙに駆動するために図９に示すそれと同様な配置で使用され得る。

【０１３７】

アクチュエータ３６０は、その他のアクチュエータと比較して非常に薄型に形成し得る。例えば、アセンブリは、約３又は４ｍｍの厚さ、その他の「Ｅ」コアアクチュエータの約半分の厚さ未満に形成し得る。磁気学上の設計は、最適な動作を得るために繰り返しが可能である。直線性及び移動止めの力は厚さに代替し得るものとなる。

【０１３８】

優位点には、ラップトップコンピュータ、ＰＤＡ、その他の携帯用装置のために適した平面状の、薄い設計が可能となることが含まれる。可動磁石を使用した手法では、大きな空隙を必要とせず、このため、ラップトップコンピュータの触感フィードバックにとってより魅力的なものとなる。典型的な「Ｅ」コアは、１０ｍｍ×２０ｍｍ×８ｍｍであり、大抵のＤＣモータより小さく、同等の力及びパワー消費を備える。更に、これは、直接駆動用の配置であるため、アクチュエータとタッチパッドとの間に何ら伝動装置は必要とされない。効率的で、低コストで、製造が容易な構成部品によって、アクチュエータは安価に

生産し得るものとなる。アクチュエータは、従来のタッチパッドＰＣＢ基板及びモジュールを使用して組み立てるだけで済むようになる。欠点の一つとしては、通常の磁性引力が存在し、それによってサスペンションが必要となることがある。各ローラ及び／又はフレキシャ及び刃形のサスペンションは、磁性の通常引力と協働させるべく、ある形態において使用し得るものである。

【０１３９】

アクチュエータ３６０は、一般に、良好な帯域幅を与えるものである。より大きな（例えば、＞１ｍｍ）の移動量が得られる。これら形態では、発泡材を前記強磁性部材の反対側の末端を支持するために使用し、剥ぎ取りモードで操作される発泡材のサスペンションが大部分となる小さなバネ定数を有する復元バネを有する。可聴ノイズもまた発泡材及び／又はローラを使用することで減じることができる。触感動作が良好である間、面の移動量が十分に小さいため、ユーザがカーソルを卓上で動かすべく指をタッチパッド上で動かす際に、面の移動量は、カーソルの動きに目立った影響を与えない。

【０１４０】

図１６ａ及び図１６ｂは、図１５ａ～図１５ｃに示す「フラットＥ」アクチュエータの別の形態３８０を示す表面側及び底面側の斜視図である。強磁性部材３８２（又は、他の形態における積層体）は、略「Ｅ」構造を有し、更にＥ中央ポール３８５に巻き付いたコイル３８４を有している。二つの棒状の磁石３８６がＥ中央ポール３８５を横切って、形態３６０と同様にして、空隙が強磁性部材３８２と磁石との間に形成されるように位置している。金属平板３８８（例えば、鉄）が磁石３８６に連結され、前記強磁性部材及び磁石に平行に設けられている。保持器３９０が中央のレイヤーに設けられており、そこでは、ローラ３８９（破線で示される）が保持器３９０の開口内に配置され、平板３８８を前記強磁性部材について横方向への移動を可能としている。タッチパッド又はタッチスクリーン（図示せず）を、部品３８２を（他の装置に）取り付けると共に平板３８８の表層に強固に連結することができる。その代りに、タッチパッド又はタッチスクリーンは、平板３８８を（他の装置に）取り付けると共に、部品３８２に連結することもできる。

【０１４１】

形態３８０は、柔軟性のあるサスペンションをも備え得る。それは、中央のレイヤーの柔軟な保持器３９０に連結し得るもので、また、鉄製の平板３８８及び強磁性部材３８２の間にこのように効果的に連結されている二つの連結部材３９２を備え得る。該連結部材３９２は、両末端部３９４で鉄製の平板３８８に着設され、保持器のレイヤー３９０に両末端部３９６で連結されている（又は該保持器のレイヤーに単一のプラスチックの部品として成形されている）。各連結部材は、細い部分３９８及び太い部分４００を有している。

【０１４２】

作動時においては、電流がコイル３８４を通して流れ、その電流により磁力が誘起され、その結果、磁石３８６によって平板３８８（及びタッチパッド）が軸４０２で示すように動く。連結部材３９２を含むサスペンションによって平板３８８が磁性通常力及びその他の力による歪みから防護される。各連結部材３９２が平板３８８の動きを順応させるべく屈曲し、そこでは、細い方の部分３９８が最初に屈曲し、該屈曲の境界が部分３９８に到達したときに太い方の部分４００が屈曲する。その細-太の構成は、より太い（より剛性の高い）横材がかみ合うまでバネの中央への付勢動作を可能とする。それは、動きを停止させるためのより柔らかい感触を与える。動きに対する最終的な制限は、両停止部４０４のいずれかが平板３８８の裏面の末端部を叩くことによってもたらされる。

【０１４３】

上述した柔軟なサスペンションは、平板及びタッチパッドの横方向への望ましい動きを効果的に可能とする。これは、平板３８８の更なる安定な動きを生成し、平板３８８を長い間その位置で浮動させることがない。更に、前記サスペンションは、望ましいバネの中央付勢力を平板３８８及びタッチパッドに与え、ユーザがタッチパッドへの接触を停止し、タッチパッドに力を加えたときに、該タッチパッドをその可動範囲の中心部に移動させる。

【０１４４】
図１７ａ～１７ｇは、別のフラット-Ｅアクチュエータタッチパッド形態４２０を示す図であり、それは、この種のアクチュエータを小型化し、現存するリードフレームに対し及び成形製造技術上、優位となる組立面実装装置を提供するものである。このような小型の装置は、タッチパッドモジュールにウエーブソルダーにより組み込まれ得るものであり、タッチパッドの移動（又はその代替の形態におけるｚ軸の力）のための適切な行程及び力を同時に与えるように作動し得るものである。
【０１４５】
図１７ａ～１７ｃは、複数のフラットＥアクチュエータ４２４を含むＰＣＢ４２２の平面図を示す。図示するように、アクチュエータ４２４がＰＣＢ４２２の各角部に配置され得るものとなる。図示されるよりも多いか又は少いアクチュエータが、他の形態においては、その代わりに配置し得る。複合的アクチュエータ４２２の使用により、より大きな強度の力が、出力され得るようになり、各アクチュエータ４２２をより小さな出力のものとして低コストなものとする。一の形態においては、ＰＣＢ４２２は、ラップトップコンピュータのハウジングに連結された別体のＰＣＢである。タッチパッド（例えば、ＰＣＢ４２２と異なるそれ自体のＰＣＢを備えるもの）は、更に、アクチュエータの移動部分（例えば、図１７ａに示されるパッド４２６）に連結される。別の形態においては、ＰＣＢ４２２は、タッチパッドであり、アクチュエータの可動部分は、ラップトップコンピュータの取り付け面、例えば、ハウジングに連結されている。このような形態においては、アクチュエータ４２４は、タッチパッドの周囲に拡がるハウジングの周縁部によって、ユーザの視野内にあるＰＣＢ４２２の中央部を残してユーザの視野から外され得る。
【０１４６】
図１７ｄは、ＰＣＢ４２２の一末端部を示す側面斜視図であり、それは、タッチパッドから別体化されており、フラットＥアクチュエータ４２４を含む。タッチパッド／ＰＣＢ部材４２８は、アクチュエータ４２４の可動部分４３０に連結されている。
【０１４７】
図１７ｅは、図１７ａに示すＰＣＢ４２２の底面側の一形態を示す斜視図であり、そこでは、フラットＥアクチュエータ４２４がＰＣＢ４２２の底面側に面実装されている。これは、「手動配置」構成部品として実施されたものであり、好ましくは、自動面実装技術の配列設備を使用したものであることが良い。該「Ｅ」強磁性部材４３２は、ＰＣＢ４２２に取り付け得るものであり、これにより、アクチュエータの磁石及び鉄製の支持板が動く。
【０１４８】
図１７ｆ及び１７ｇは、それぞれ３本のポールを有し、上述したフラットＥアクチュエータと同様に作動するフラットＥアクチュエータ４２４の表面側及び底面側からみた斜視図を示す。強磁性部材４３２は、Ｅ字状に成形され、中央のポールに巻き付いたコイル４３４を備える。フレキシャ４３６は、磁石４３８及び鉄製の支持板４４０の、強磁性部材４３２及びコイル４３４に対応した動きを可能とする。タッチパッド（図示せず）は、鉄製の支持片４４０に連結され、Ｅ積層部材４３２／コイル４３４は、図１７ａ～１７ｅに示す形態に示す如く、（他の部材に）取り付けることができる。その代わりに、支持片４４０及び磁石４３８を（他の部材に）取り付け、タッチパッドを可動の強磁性部材４３２に連結することもできる。
【０１４９】
上述したようなフラットＥアクチュエータは、タッチパッドモジュール又は手のひら載置面を直接移動させるために使用し得る。説明された形態においては、フラットＥアクチュエータの総厚みは、３ｍｍ又はそれ未満とし得る。従来のタッチパッドの生産ラインに組み込み可能なフラットＥ磁石アセンブリは、サイズ、製造効率及びスケールメリットの観点から好ましい形態となる。
【０１５０】
他の形態においては、その他の可動磁石アクチュエータ設計、及びその他のボイスコイル

アクチュエータ設計、例えば、米国特許第６，１６６，７２３号及び６，１００，８７４号に記載されているものを使用することができる。

【０１５１】

他の形態においては、他種の入力用面又は表示スクリーンが、ここで説明するいずれかのアクチュエータを用いて同様に移動させることができる。例えば、携帯端末装置（ＰＤＡ）の表示スクリーン、又はモニタ又はＣＲＴ上のタッチスクリーンを被っている入力センサ装置の如く綺麗な面は、触感フィードバックを与えるべくＸ及び／又はＹ方向（スクリーンの面に平行に）に同様に移動させ得る。このような綺麗なスクリーン移動体の一例は、ＡＴＭ機であり、そこでは、ユーザが一般にタッチスクリーン上に情報を入力する。触感フィードバックは、そのような入力をより親しみやすく、そして、標準以下の視力を有する人々にとって容易なものとする。触感フィードバックは、ユーザの指が、画像表示されたボタン上にあるとき、表示することができるか、又は、異なる触感覚によって、特定された表示ボタンを確認することができる。これは、可動のカーソルがないことから、多くのＡＴＭへの適用例において有用となり得る。触感フィードバックは、雑音の多い環境、例えば、音が容易に聞き取ることができない交通量の多い場所においてもユーザを補助し得るものとなる。

【０１５２】

ここに説明した形態は、ユーザがペン先又はその他の物体をタッチパッド、タッチスクリーン、又は入力領域上へのデータの入力に用いる形態においても触感フィードバックを与え得るものとなる。触感覚は、タッチパッド（又はその他の移動面）から、ペン先又はその他の物体を通してユーザに伝達し得るものとなる。

【０１５３】

その他の機能

触感フィードバックに関する人的要因は、ある形態では、力の過負荷からの防御を含む。理想的には、非慣性フィードバックアクチュエータ及び伝達設計、例えば、移動する面及び異なる面等としては、アクチュエータが、該アクチュエータへの負荷又はアクチュエータの移動範囲内の位置とは無関係に忠実さをもって大きな力を生成することが望まれる。換言すれば、ユーザの指又は手は、限界に逆らってアクチュエータを動かすこと、又は、振動周期が半分に減衰した移動条件の終わりに到達することがないことが望まれる。このため、ユーザの負荷から本質的に分断されているアクチュエータ及び伝達機構を設計することが望ましい。これの一例は、図１６ａ～１６ｂに示す形態の如く、硬いサスペンションによる非常に高いバネ中央付勢力を有するＥコアアクチュエータが挙げられる。強力なアクチュエータは、このバネ力を容易に克服し、タッチパッドの面における指によるドラッグの力は、アクチュエータの出力全体に対して比率の小さなものに過ぎないものとなる。力の弱いアクチュエータは、よりコンプライアンスの良いサスペンションを必要とし、これにより、ユーザのインタラションが振動と干渉し、直線状の出力が生成されなくなる可能性がある。

【０１５４】

別の人的要因に関する触感フィードバックの問題には、ある形態では、可聴性がある。手のひら載置面及び慣性アクチュエータアセンブリの使用は、例えば、触感の共鳴板による不可避な副作用である音響を生じる結果となる。負荷が加わった面、例えば、ユーザが、ハウジング又はタッチパッドに触れているときは、弱い音が放射され、依然として非常に良好に力を伝達する。したがって、ある形態では、ユーザの手が存在する場合にのみ出力が可能となるように、負荷測定の装置を使用してユーザの手が移動面上に存在するか否かを測定しても良い。

【０１５５】

ラップトップコンピュータのタッチパッド又は類似の入力装置に触感機能を付与する場合のコストを削減するため、ある形態では、ラップトップコンピュータ、ＰＤＡ、又はその他の装置内の従来の音響電子機器を使用できる。例えば、従来の音声アナログ入力（例えば、デジタルーアナログコンバータ）及び音響パワーアンプは、上述したタッチパッド又

はその他のラップトップコンピュータの構成部品における触感フィードバックのために使用されるアクチュエータを、補助のマイクロプロセッサ及び／又は補助のパワー供給電子機器を付加する必要を生じることなく駆動し得るものとなる。ノッチ・フィルタ又は音響信号からのその他のノイズ除去装置が、触感フィードバック信号を生成する際に使用し得る。例えば、触感効果制御用信号を音声スペクトルの非可聴域に供給し、フィルタリングされてこれら制御信号が触感アクチュエータに供給され、その一方、可聴域における残余の信号がラップトップコンピュータの音声スピーカに通じ得るようにする。或いは、可聴域外の音声信号が含まれない専用信号をフィルタリングするか又は触感フィードバックアクチュエータを制御させるようにする。

【０１５６】

さらに、従来、多くのラップトップコンピュータ上では、ソフトウエアによって、パワーレベルを表示し、ユーザに警告し、又は電源パワーを保存するためにラップトップコンピュータの電源を落とすべく、ラップトップコンピュータの電源パワーが探知されている。この探知用ソフトウエアは、触感フィードバック用アプリケーションに組み込み得る。例えば、電源パワーがあるレベルを下回ったとき、触感フィードバックソフトウエアのルーチンは、パワーレベルを縮小するか、又はユーザへの出力を停止することすらし得る。これは、力の強度を落とすこと、又は触感効果を組み込んでいるＧＵＩにおける画像物体のタイプ又は数字を減じることによって達成され得る。これは、触感の持続時間を短縮すること、例えば、通常５０ｍｓである効果を４０ｍｓに減少させ得ることによっても達成し得る。また、これらの組み合わせを使用し得る。最後に、いくつかのラップトップコンピュータでは、例えば、低出力設定では電源を長く持続させるような、ユーザが必要に応じて選択し得る高出力、中出力、及び低出力の異なる設定がされている。前記触感フィードバック制御は、この設定の中に組み込むことができ、この設定によって、同様に管理し得るものとなる。例えば、ユーザが低出力モードを選択した場合、上述したように、触感効果に必要なパワーを減少させるべく触感フィードバック制御機器を適用し得る。

【０１５７】

図１８は、本発明に係るタッチパッド４５０の平面図である。タッチパッド４５０は、ある形態では、単に位置決め装置として使用され得るものであり、そこでは、タッチパッドの全体領域が、カーソルの制御を提供する。他の形態においては、パッド上に機能によって異なる領域が設計され得る。これら領域を有するある形態では、各領域には、該領域の下部に配置されるか、或いは該領域に物理的に関連付けされたアクチュエータが設けられており、一方、その他の領域を有する形態では、タッチパッド４５０全体に力を与える単一のアクチュエータが使用され得る。図示する形態においては、中央カーソル制御領域４５２がカーソルを配置するか、又はラップトップコンピュータ若しくはその他の装置によって表示される表示域として使用される。

【０１５８】

前記タッチパッドのカーソル制御領域は、グラフィック環境及び／又は該領域におけるイベントと、制御されたカーソルとのインタラクションに基づいて、タッチパッド上に力を出力させる源となり得る。ユーザは、指又はその他の物体を領域４５２内で動かし、例えば、その結果、カーソル２０を動かすのである。力は、好ましくは、該カーソルと表示された画像物体との間のインタラクションに関連付けられていることが良い。例えば、素早く目標の強度に上昇し、その後、停止しするか、又は、０若しくは微小な強度に減衰して復帰する単一の力の刺激である衝撃又は「パルス」感覚が出力され得る。タッチパッド４５０は、一の方向に、又は、ｚ軸若しくはその他の軸における振動として、慣性触感フィードバック形態において慣性的に衝撃力を与えられ得るものとなるか、或いは、タッチパッドは、前記パルスを与えるべく、一の方向に移動されるか若しくは一又は複数回振動され得るものとなる。振動感覚もまた出力することができ、それは、一般には周期的である経時的に変化する力である。該振動は、タッチパッド４５０又はその各部を、繰り返して複数回振動させ得るものとなり、ホスト又はローカルマイクロプロセッサによってホストアプリケーションにおいて起こる特定される効果をシミュレートさせるべく出力され得る

ものとなる。

【０１５９】

タッチパッド上に出力され得る別の種類の力感覚は、手触りの力である。この種の力は、パルス力に類似しているが、タッチパッド及び／又はグラフィック環境におけるカーソルの配置場所における領域上でのユーザの指の位置に依存するものである。したがって、手触りにおける突起部は、グラフィック環境における突起部の位置をカーソルが通過したか否かに依存して出力され得る。この種の力は、空間に依存するものであり、例えば、力はカーソルが指定された手触り領域を通過する際のカーソルの位置に依存して出力される。即ち、カーソルが手触りの「突起」の間に位置するとき、何らの力も出力されず、カーソルが突起上を通過するとき、力が出力される。これは、カーソルが格子上をドラッグされて通過する際に、パルス信号を送信するホストコンピュータによって達成され得るか、又は、別体化されたタッチパッドプロセッサを触感フィードバックのためにタッチパッドに対して専用化し得るものとなる。そして、手触り効果がローカル制御（例えば、ホストコンピュータによって手触りパラメータを有する高レベルコマンドが伝送され、タッチパッドプロセッサによって感覚が直接制御される）を使用して達成される。その他の場合においては、ユーザに、その指（又はその他の物体）のタッチパッド上の現在の速度に依存した振動を与えることによって手触り感が実行され得るものとなる。その指が静止しているとき、該振動は停止した状態となる。指が早く動くにつれ、該振動の周波数及び強度は増加する。この感覚は、タッチパッドプロセッサ（存在する場合）又はホストコンピュータによって制御され得る。その他の空間的な力感覚もまた、出力され得る。加えて、ここで説明されている力感覚のいずれかは、同時に出力され得るか、或いは、要望どおりに組み合わせられる。

【０１６０】

異なる種類の画像物体が触感覚と関連付けられる。触感覚は、カーソルと、ウィンドウ、メニュー、アイコン、ウエッブページリンク等との間のインタラクションに基づいてタッチパッド上に出力され得る。例えば、「突起」又はパルスは、カーソルがウィンドウの境界を通過した際に、タッチパッド上にカーソルの位置についての信号をユーザに送るべく出力され得る。その他の関連するインタラクションにおいては、速度制御又はスクロールの機能がタッチパッド（カーソルの使用を通して）で実行されるとき、感覚が速度制御機能に関連して出力され得るものとなる。更に、タッチパッド上に出力された力の強度は、ユーザから独立したイベントを含んだグラフィック環境におけるイベントやインタラクションに依存し得るものとなる。これら力感覚は、ゲーム又はシミュレーションにおいても使用し得る。これら及びその他の触感覚については、米国特許第６，２１１，８６１号で説明されている。その他の制御機器又はグリップ装置は、本発明のタッチパッドを、カーソル又はその他のコンピュータにより生成された環境における画像物体を操作するべく、ゲームパッド、マウス、若しくはトラックボール装置、又は圧球体若しくは類似物を含んでそのハウジングに備え得るものとなる。

【０１６１】

タッチパッド及びタッチスクリーンの形状によって、ユーザがタッチパッドに検知されるように加える圧力の量を変化し得る場合がある。これによって、多様性のある触感覚が、少なくともある程度、検知された圧力に応じて決定されるようになる。例えば、周期的な振動が、検知された圧力に依存する周波数を有して出力され得るものとなる。或いは、出力された触感覚の利得（強度）は、検知された圧力に基づいて調整し得るものとなる。普段、強めの圧力でタッチパッドを使用する傾向にあるユーザは、常に効力が発揮される自動強度増大機能を選択し得る。

【０１６２】

タッチパッドとタッチスクリーンの他の形態は、ユーザの「ジェスチャー」、又は、カーソル制御領域若しくはその他の領域上の標識記号をなぞることによるショートカットを入力可能としており、それは、コマンド又はデータとしてプロセッサによって認知されるものである。触感覚は、特定されたジェスチャーに関連付けされるか、依存し得るものであ

る。例えば、モードの確認は、モード確認用ジェスチャーが認知されたときに、特定される触感覚によって触感的に伝えられ得るものとなる。ジェスチャーから認知される文字は、それらと関連付けされる特定の触感覚をそれぞれ有し得るものである。大抵のタッチパッド形態においては、ユーザは、画像物体又はメニューアイテムをタッチパッドを軽く叩くことで選択することができる。いくつかのタッチパッドは、「半分の強度の叩き」又は二度の叩き、即ち、ユーザが軽く叩き、そして再び叩き、指を動かしているときにパッド上で指又は物体を保持することを認知することができる。例えば、そのようなジェスチャーは、物体がカーソルと共に動く「ドラッグ」モードを与え得る。ユーザがそのようなドラッグモードにあるとき、振動又はその他の触感覚がユーザに本モードがアクティブ状態であることを示すために出力され得る。

【０１６３】

上に規定したように、タッチパッド４５０は、メインのカーソル制御領域４５２から別体化された入力を与える制御領域をも有し得るものとなる。ある形態では、異なる領域が、線、境界、又はタッチパッド４５０の面上の手触り（及び／又はコンピュータ１０からの音）で物理的にマークされ得るものとなり、これによって、ユーザが視覚的、聴覚的、及び／又は、触覚的に、タッチパッド上のどの領域に触れているかが判るようになる。

【０１６４】

例えば、スクロール又は速度制御領域４５４ａ及び４５４ｂは、速度制御タスクを実行するべく入力を与えるために使用し得るものとなる。例えば、文書のスクロール、値の調整（例えば、音声ボリューム、スピーカバランス、画像モニタの輝度等）、又は、ゲーム又はシミュレーション中における視野への批評文／タイトルの挿入である。領域４５４ａは、指（又はその他の物体）を該領域内に置くことによって使用され得る。そこでは、領域の上部分では値が増加し、スクロールアップ等し、領域の下部分では値が減少し、スクロールダウン等する。タッチパッド上に加わっている圧力の量を計ることが可能な形態においては、該圧力の量で直接に調整の速度を変化させ得る。例えば、より大きな圧力では文書のスクロールをより迅速にする等である。領域４５４ｂは、水平（左／右）スクローリング又は異なる値、視野等の速度制御の調整に同様に使用し得る。

【０１６５】

特定された触感効果を制御領域４５４ａ及び４５４ｂに関連付けることができる。例えば、速度制御領域４５４ａ又は４５４ｂを使用しているとき、特定される周波数の振動がタッチパッド上に出力され得る。複合アクチュエータを有する形態においては、領域４５４ａ又は４５４ｂの直下に配されたアクチュエータは、「アクティブ」（現在使用されている）領域に対してより局在化された触感覚を与えるために活動させ得るものとなる。領域４５４の部分が、速度制御のために押されると、ページが、何時、スクロールされたか、何時、特定される値が通過したか等を合図するべくパルスがタッチパッド（タッチパッドの領域）上に出力され得る。振動もまた、ユーザが領域４５４ａ及び４５４ｂに触れている間、連続して出力され得る。

【０１６６】

他の領域４５６もまた、タッチパッド４５０上に配置され得る。例えば、領域４５６のそれぞれは、ボタンのような、小さな四辺形状の領域とし得るものであり、それにはユーザが、指し示された領域に関連した機能を開始するために指し示し得るものである。領域４５６は、次のようなコンピュータの機能を開始することができる。例えば、プログラムの実行、ウィンドウの開閉、ウエッブブラウザにおけるウエップページの列に「フォワード」又は「バック」をかけること、コンピュータ１０の電源を入れること、又は「スリープ」モードを開始すること、メールのチェック、ゲーム中の銃撃、バッファからデータをカットし、又はペーストすること、記憶装置にファイルを保存すること、フォントを選択すること等である。領域４５６は、アプリケーションプログラム中に設けられた機能若しくはボタンを複製し得るものであるか、又は新しい、異なる機能を備え得るものである。

【０１６７】

領域４５４と同様に、領域４５６は、それぞれ触感覚に関連付けられ得るものである。例

えば、領域４５６は、ユーザに選択されたときにパルス感覚を与え、機能が選択されたときに直ちにフィードバックを与え得るものである。例えば、ユーザが指又は物体によって領域４５６、４５２、又は４５４上を選択のために軽く叩いたときにパルスのような触感覚が出力され得る。ボタンが押された深さに基づいて出力の度合いを変える物理アナログボタン、一以上の領域４５６を、ユーザがタッチパッドに及ぼす圧力に基づいて、比例したとびとびの出力、又はアナログ出力によって、アナログ類似のボタンのようにし得る。

【０１６８】

更に、同様な種類の領域を同様な感覚の触感覚に関連付けることができる。例えば、それぞれワープロに関連した領域４５６は、指し示されたときに、それぞれゲームに関連した領域４５６が異なる強度又は振動のパルスを生じ得る一方で、特定される強度のパルスを生じ得る。更に、ユーザが指し示す物体を一の領域４５４又は４５６から他に移動させたとき、触感覚（例えば、パルス）がタッチパッド４５０上に出力され、これによって、ある領域の境界がすれ違ったことが意味される。例えば、素早くゼロ強度まで減衰する高周波振動は、指し示す物体が指定された領域に入ったときに出力され得る。これは、領域４５４及び４５６にユーザが知り得ない可能性のある境界を合図することから有用なものとなり得る。これは、また、領域のサイズ及び／又は位置の再配置を可能とし、ユーザに新しいレイアウトを触感的に迅速に習得させることにもなる。各領域は、グラフィック環境において領域を規定する「エンクロージャ」、及び、カーソルが入退するとき、並びに、カーソルがエンクロージャ及びそのような触感覚と関連する特定される境界で動かされたときに出力される異なる触感覚にもまた関連付けられる。

【０１６９】

加えて、領域は、好ましくは、サイズ及び外形において、並びに、それらが関連付けられる機能において、プログラム可能であることが良い。したがって、領域４５６の機能は、グラフィック環境中で実行中のアプリケーションプログラムに基づいて及び／又はユーザの嗜好によるコンピュータ１０への入力及び／又はコンピュータ１０への保存に基づいて変化し得るものとなる。好ましくは、それぞれの領域のサイズ及び配置は、ユーザによって又はアプリケーションプログラムによって調整し得ることが良く、そして、複数の領域のいずれか又は全体は、必要時には消去し得ることが良い。更に、ユーザは、好ましくは、特定された触感覚を特定された領域、又は必要時にはこれら領域に関連した機能の種類に基づいた種類の領域に割り当て得ることが好ましい。異なる触感覚は、カリフォルニア州、サンノゼのイマージョン社から入手できるイマージョンスタジオ（登録商標）等のツールにおいて設計され得る。

【０１７０】

領域４５４及び４５６が、タッチパッド４５０の物理的領域を必要としないことは特筆すべきである。換言すれば、タッチパッドの面全体が、コンピュータのプロセッサに接触するユーザと、異なる領域が配置されている場所を指定し得るコンピュータ上のソフトウエアとの座標を備えていることを必要としているに過ぎないということである。コンピュータは、その座標を解釈して実行し得るものであり、ユーザが接触している場所に基づいてタッチパッドの入力信号をカーソル制御信号又は異なる種類の信号、例えば、速度制御、ボタン機能等として解釈して実行し得るものである（例えば、ドライバプログラムは、必要時には解釈して実行する機能を備え得ること）。タッチパッドマイクロプロセッサは、存在するならば、その代わりに、ユーザの触れる場所に関連した機能を解釈して実行するものであり、しかるべき信号又はデータをホストコンピュータに伝えるものである（例えば、位置座標又はボタン信号）、このようにして、ホストプロセッサ又はソフトウエアを低レベルの処理手続きから開放された状態に維持するのである。他の形態においては、タッチパッド４５０は、ユーザに接触されるタッチパッドの面上に物理的にマークされた異なる領域（例えば、各領域は、異なるセンサ又はセンサアレイによって検知され得る）に基づいて、コンピュータに異なる信号を出力するように物理的に設計され得る。

【０１７１】

タッチパッド又はタッチスクリーンに触れるユーザの指又は物体に触感フィードバックを

与える、ここで説明されるいずれかの形態には、タッチパッド４５０の複数の領域が使用され得る。

【０１７２】

以上、本発明を、いくつかの好ましい形態によって説明してきたが、さまざまな変更や修正、均等形態との置換が可能なことは、詳細な説明の読み込み及び図面の観察によって考察すれば当業者には明白である。例えば、一の形態において説明された機能の多くは他の形態にも置換が可能である。更に、専門用語は、記載の明瞭性を担保するために使用したものであり、本発明を限定するものではない。

【図面の簡単な説明】

【０１７３】

【図１】図１は、本発明に係る触感タッチパッドを備えるラップトップコンピュータ装置の斜視図である。

【図２】図２は、本発明に係るタッチパッドを有するリモコン（遠隔制御機器）を示す斜視図である。

【図３】図３は、本発明に係る触感タッチスクリーンの一形態を示す平面図である。

【図４】図４は、本発明に好適に使用できる触感システムのブロックダイヤグラムである。

【図５】図５は、本発明の慣性力を利用した一形態に好適に使用できるアクチュエータアセンブリの一形態を示す斜視図である。

【図６】図６は、タッチパッドに連結された図５に示すアクチュエータアセンブリを示す斜視図である。

【図７】図７は、慣性力の触感覚を与える、タッチパッドに近接した手のひら載置面を示す斜視図である。

【図８】図８ａは、本発明において、慣性力の触感覚を与えるにあたり好適に使用できる圧電変換器を示す斜視図であり、図８ｂは、本発明において、タッチ装置を用いて触感を与えるために好適な圧電変換器の側面図及び構造である。

【図９】図９は、リニアアクチュエータにより駆動され、移動する面の一形態を示す斜視図である。

【図１０】図１０は、ロータリアクチュエータにより駆動され、移動面の別の形態を示す平面図である。

【図１１】図１１は、ボイスコイルアクチュエータによって駆動され、移動面の別の形態を示す斜視図である。

【図１２】図１２は、タッチパッドに近接して移動面の一形態を示す斜視図である。

【図１３】図１３は、ロータリアクチュエータにより一方向に移動されるタッチパッドの一形態を示す斜視図である。

【図１４】図１４は、ロータリアクチュエータにより二方向に移動されるタッチパッドの一形態を示す斜視図である。

【図１５ａ】図１５ａは、本発明において、タッチパッド又は別体の面を移動させるのに適した平面状のＥコアアクチュエータの第一の形態を示す斜視図である。

【図１５ｂ】図１５ｂは、本発明において、タッチパッド又は別体の面を移動させるのに適した平面状のＥコアアクチュエータの第一の形態を示す斜視図である。

【図１５ｃ】図１５ｃは、図１５ａ及び図１５ｂに示すアクチュエータの側面図である。

【図１５ｄ】図１５ｄは、タッチパッドに連結された図１５ａ及び図１５ｂに示すアクチュエータの斜視図である。

【図１６ａ】図１６ａは、本発明におけるフラットＥコアアクチュエータの別の形態を示す表面斜視図である。

【図１６ｂ】図１６ｂは、本発明におけるフラットＥコアアクチュエータの別の形態を示す底面斜視図である。

【図１７ａ】図１７ａは、本発明における面実装されたＥコアアクチュエータの斜視図である。

【図１７ｂ】図１７ｂは、本発明における面実装されたＥコアアクチュエータの上面図である。
【図１７ｃ】図１７ｃは、図１７ａ及び図１７ｂに示すＥコアアクチュエータの斜視図である。
【図１７ｄ】図１７ｄは、図１７ａ及び図１７ｂに示すＥコアアクチュエータの側面図である。
【図１７ｅ】図１７ｅは、図１７ａ及び図１７ｂに示すＥコアアクチュエータの斜視図である。
【図１７ｆ】図１７ｆは、図１７ａ及び図１７ｂに示すＥコアアクチュエータの斜視図である。
【図１７ｇ】図１７ｇは、図１７ａ及び図１７ｂに示すＥコアアクチュエータの斜視図である。
【図１８】図１８は、本発明において、異なる制御領域を有する触感タッチパッドの一例を示す平面図である。
【符号の説明】
【０１７４】
１０，７４…コンピュータ、１６…タッチパッド（タッチ入力装置）、７２…触感フィードバックインターフェイス装置（触感フィードバックタッチ制御機器）、８８，１５５，３００，３３６…アクチュエータ

【図１】

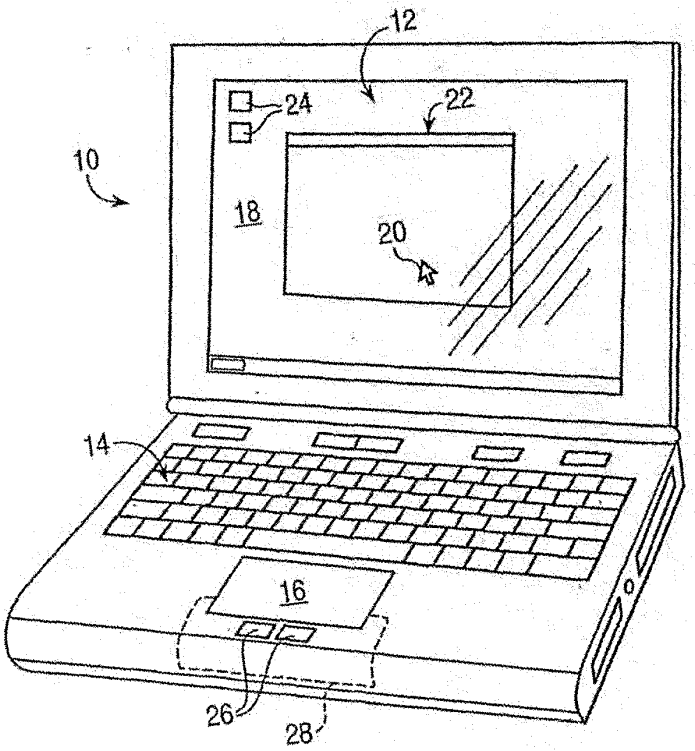


FIG. 1

【図２】

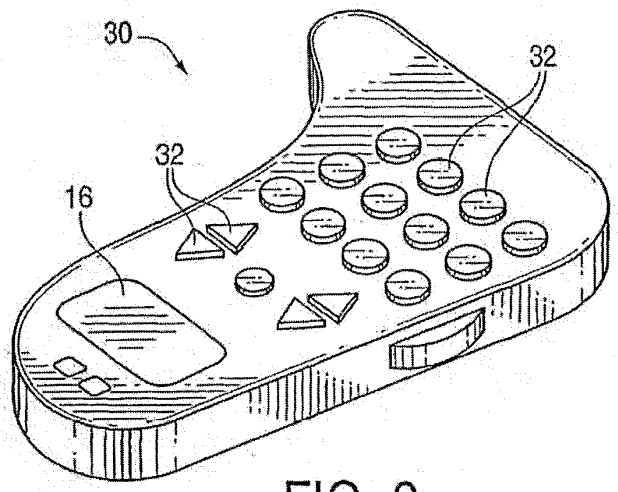


FIG. 2

【図３】

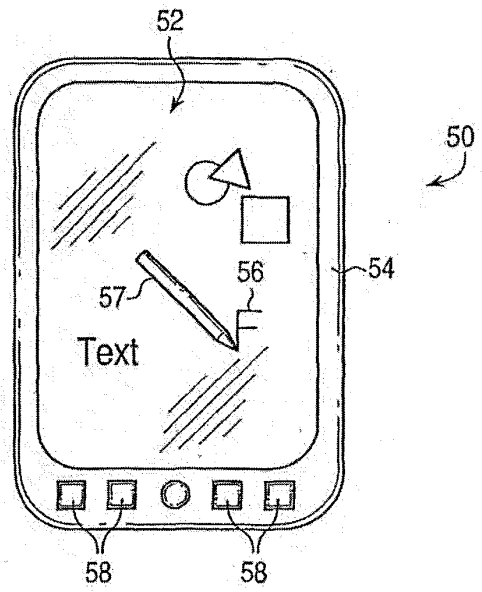


FIG. 3

【図４】

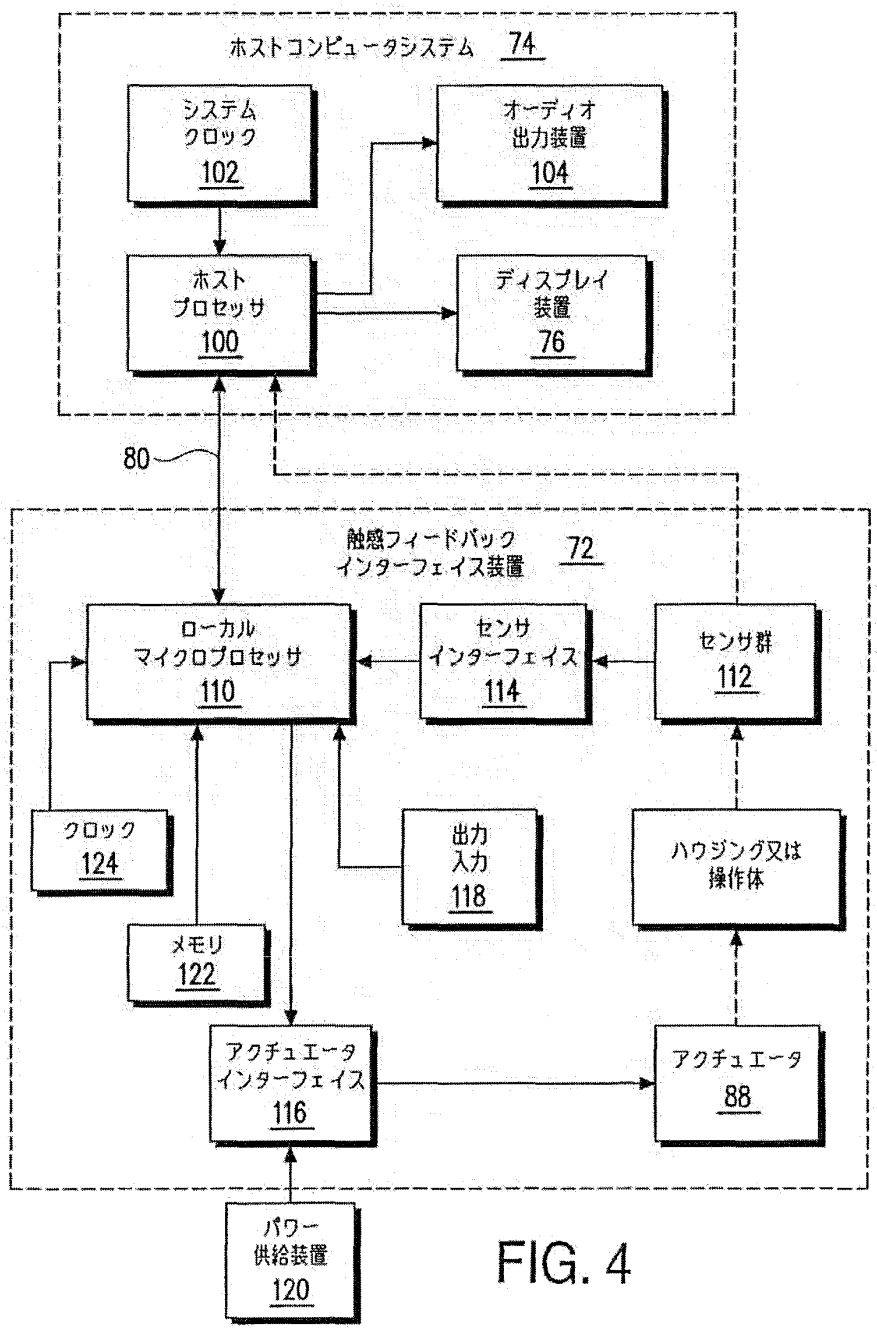

ホストコンピュータシステム 74
システム クロック 102
オーディオ 出力装置 104
ホスト プロセッサ 100
ディスプレイ 装置 76
80
触感フィードバック インターフェイス装置 72
ローカル マイクロプロセッサ 110
センサ インターフェイス 114
センサ群 112
クロック 124
出力 入力 118
ハウジング又は 操作体
メモリ 122
アクチュエータ インターフェイス 116
アクチュエータ 88
パワー 供給装置 120

FIG. 4

【図５】

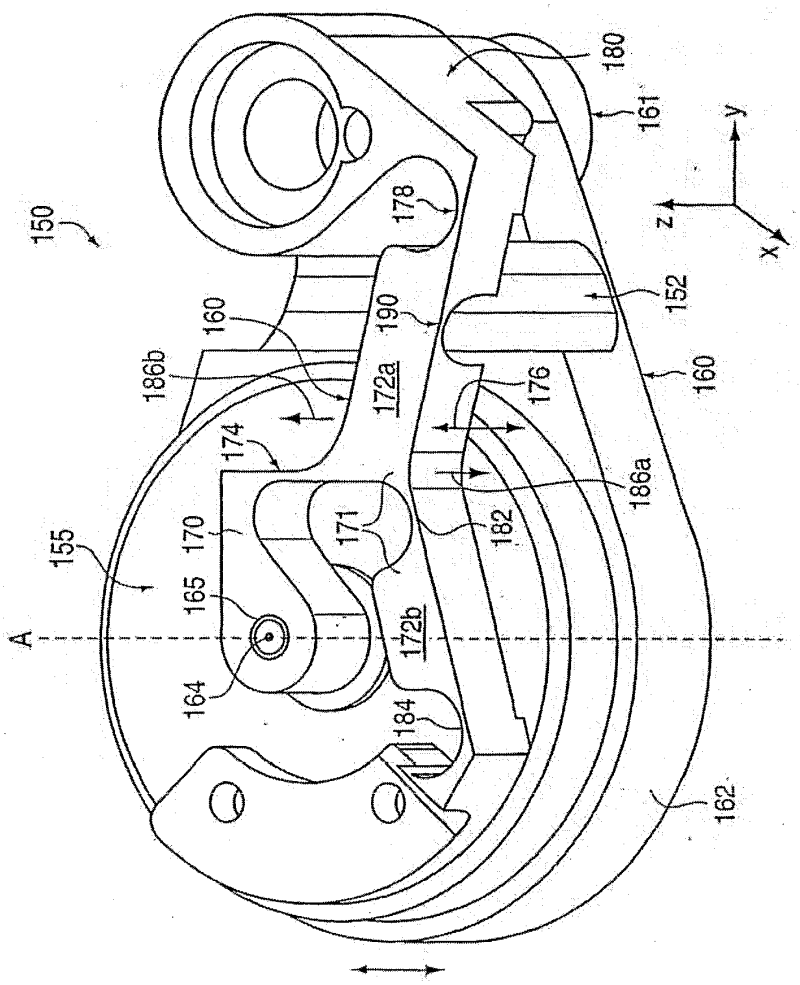


FIG. 5

EX1002 - Page 1084

【図６】

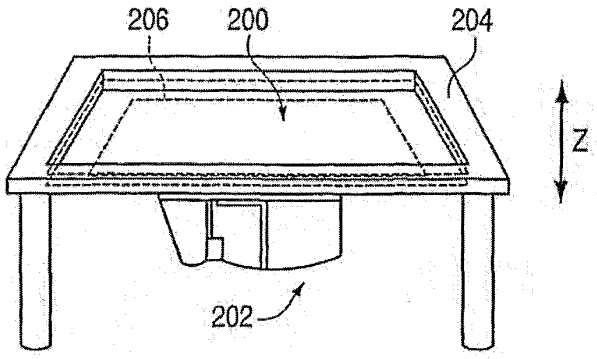


FIG. 6

【図７】

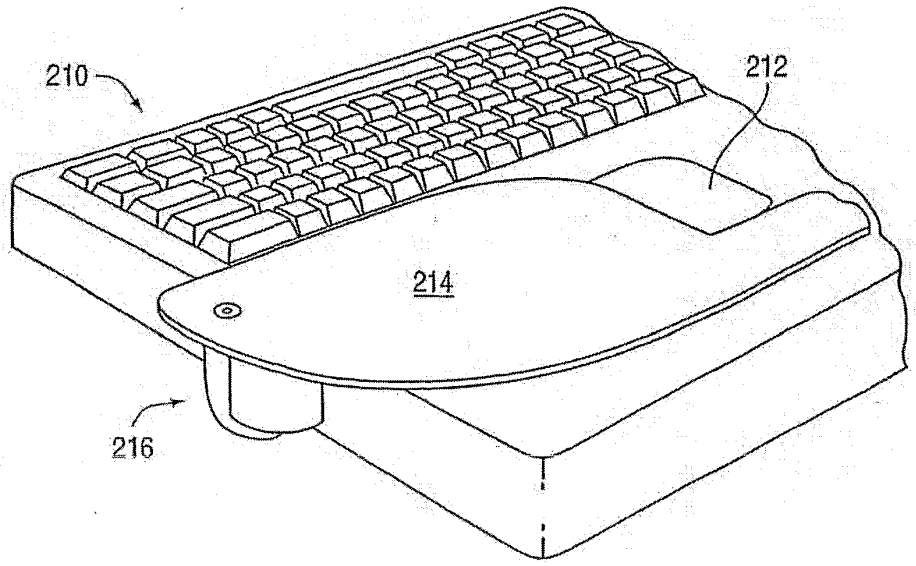


FIG. 7

【図８】

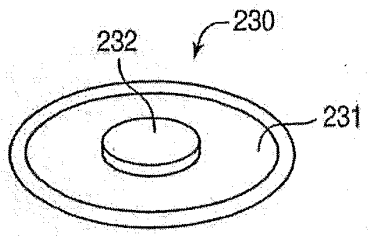


FIG. 8A

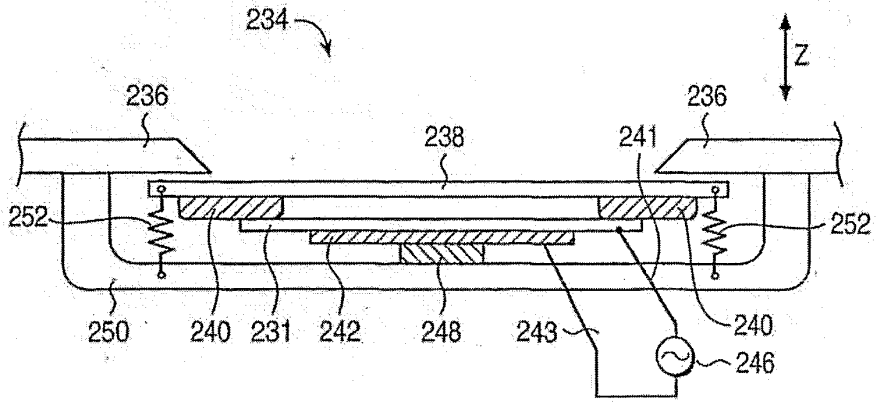


FIG. 8B

【図９】

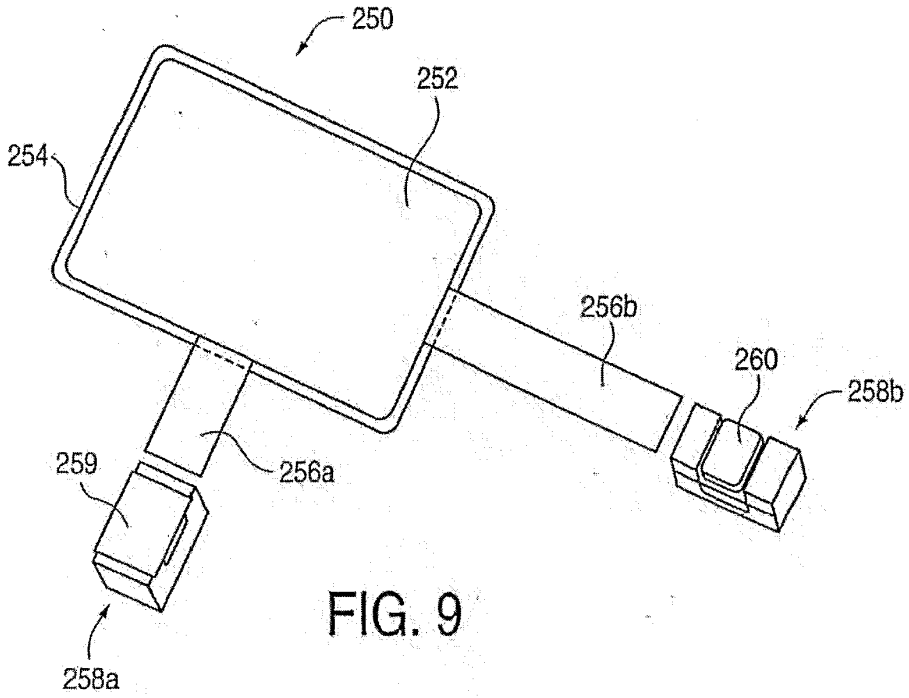


FIG. 9

【図１０】

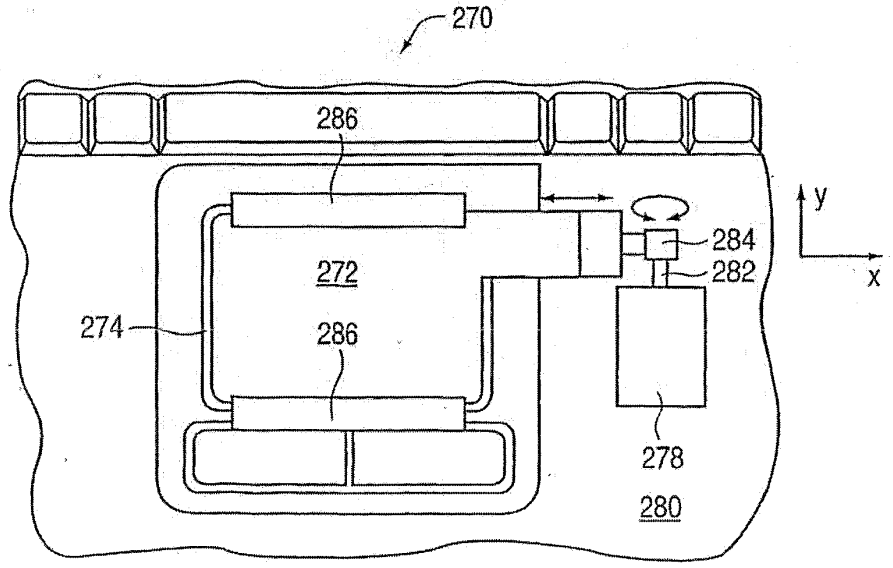


FIG. 10

【図１１】

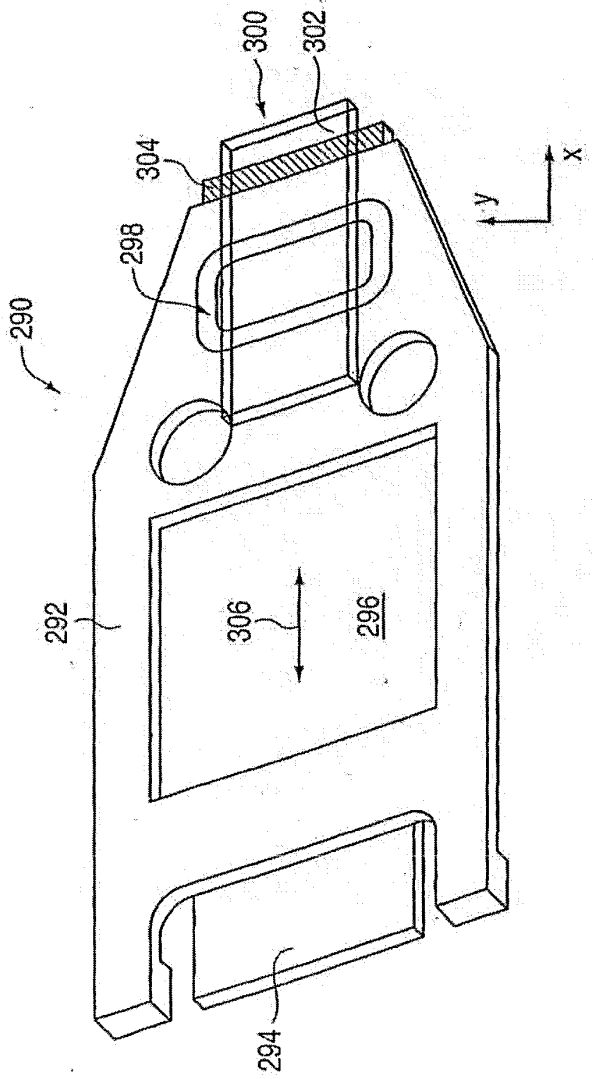


FIG 11

【図１２】

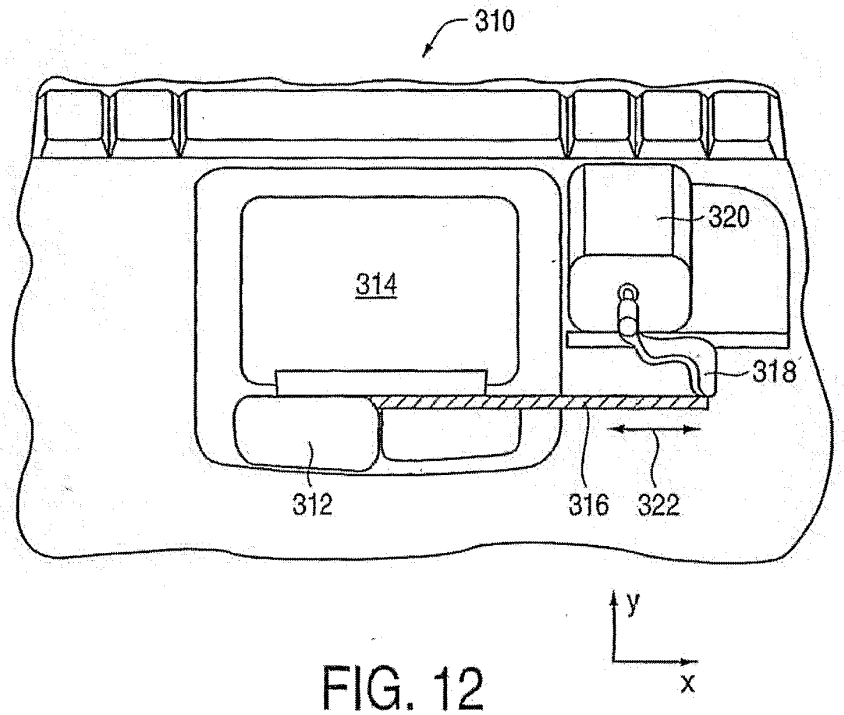


FIG. 12

【図１３】

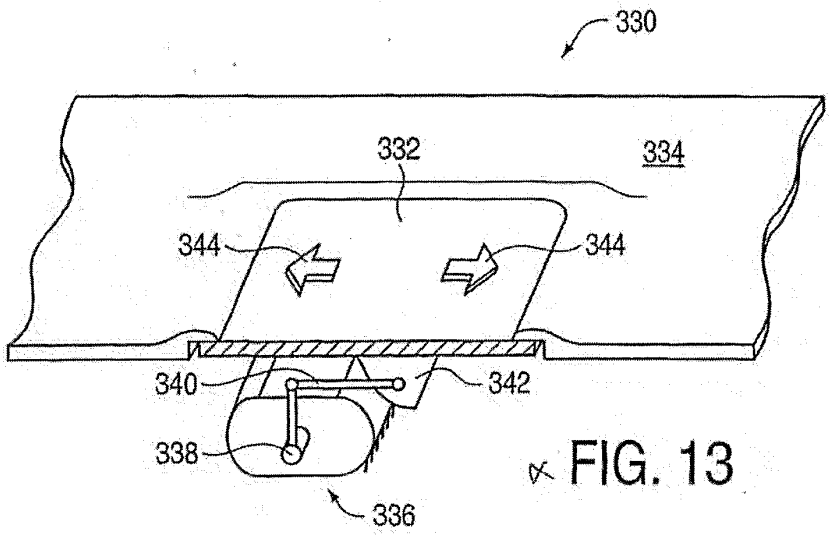


FIG. 13

【図１４】

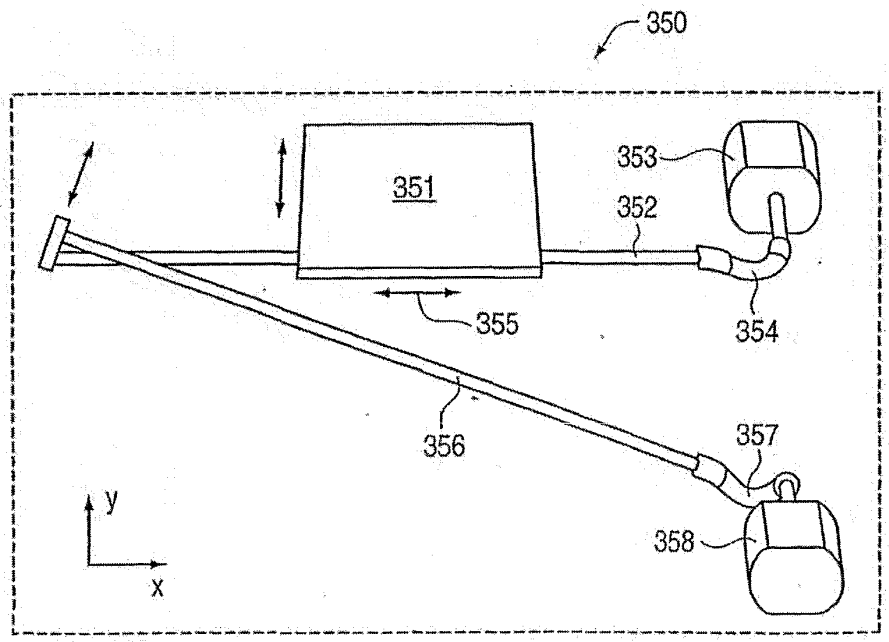
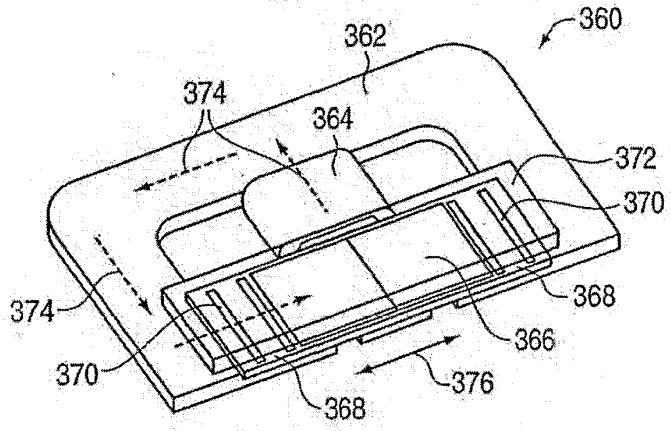


FIG. 14

【図１５ａ】

FIG. 15A



【図１５ｂ】

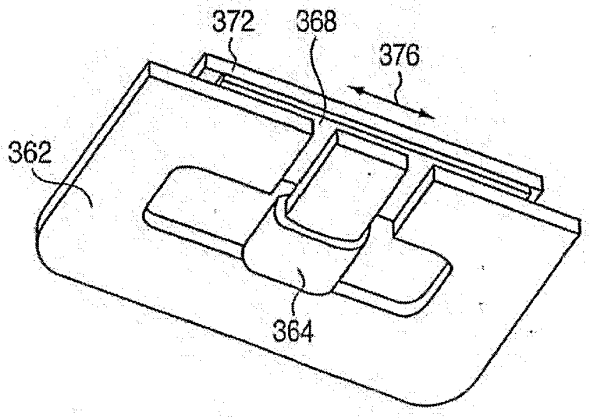


FIG. 15B

【図１５ｃ】

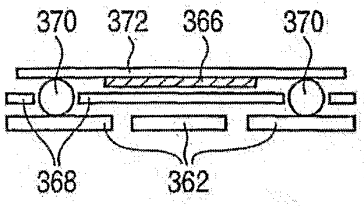


FIG. 15C

【図１５ｄ】

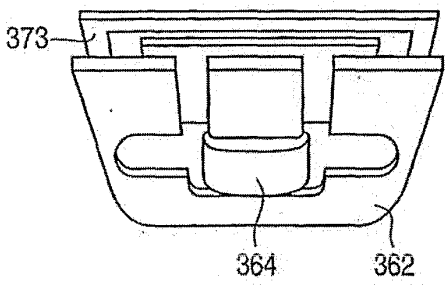


FIG. 15D

【図１６ａ】

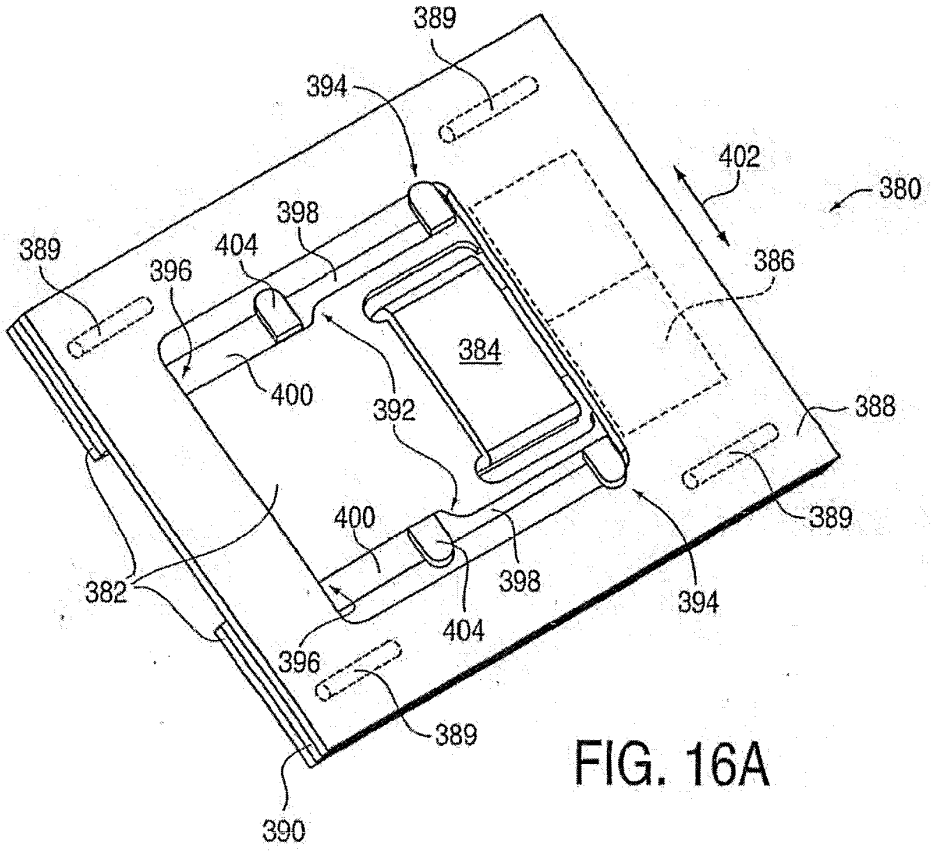

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FIG. 16A

【図１６ｂ】

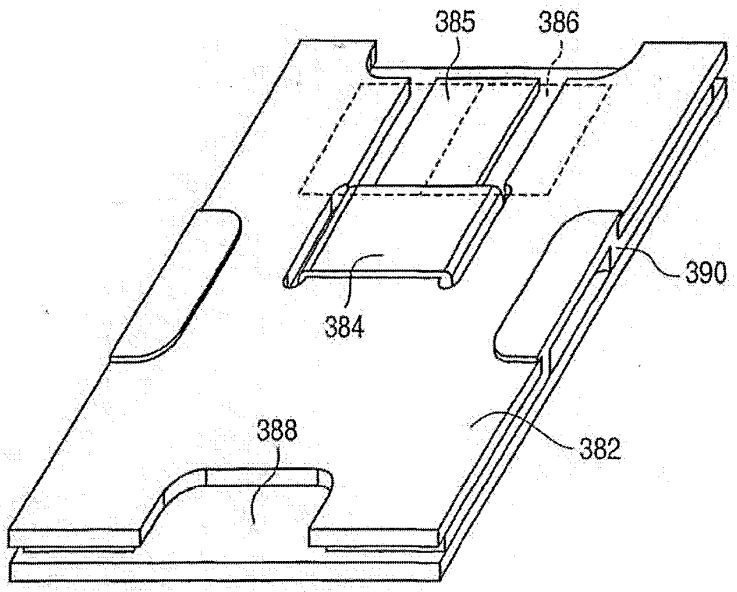


FIG. 16B

【図１７ａ】

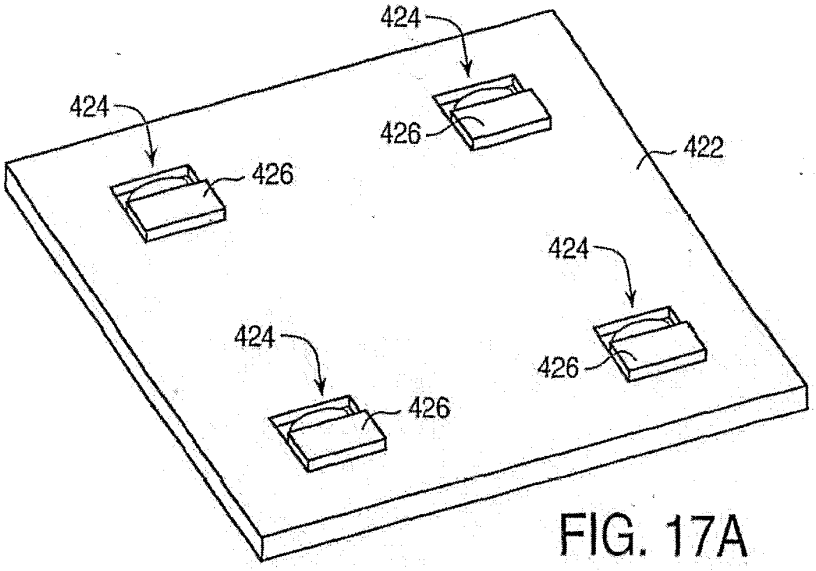


FIG. 17A

【図１７ｂ】

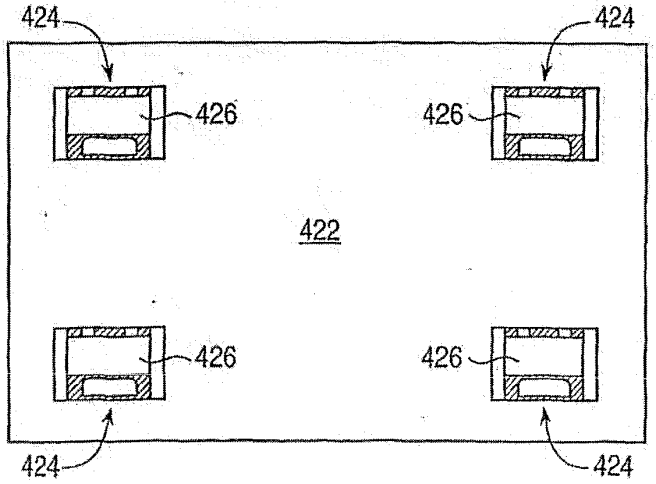


FIG. 17B

【図１７ｃ】

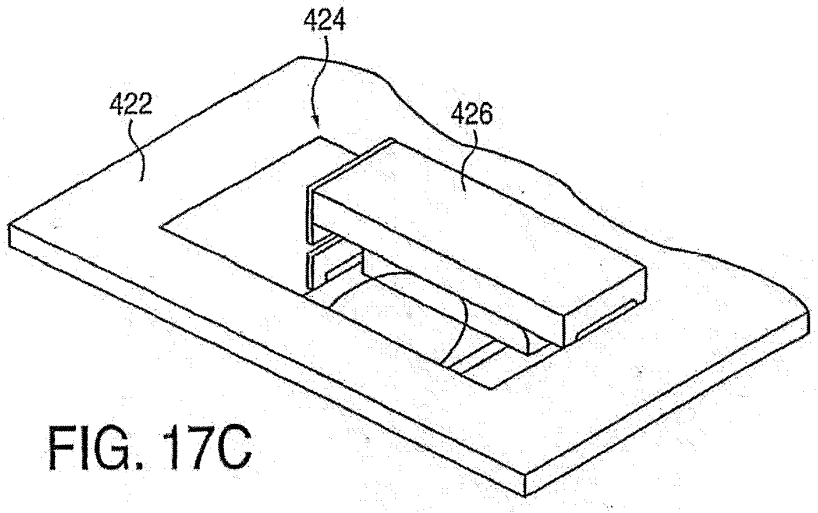


FIG. 17C

【図１７ｄ】

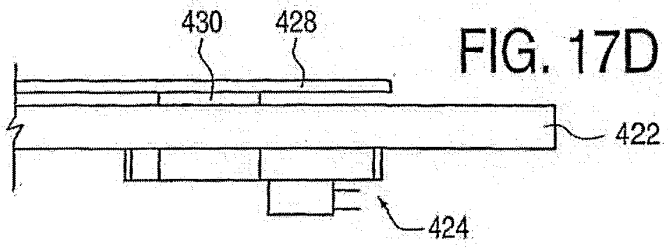


FIG. 17D

【図１７ｅ】

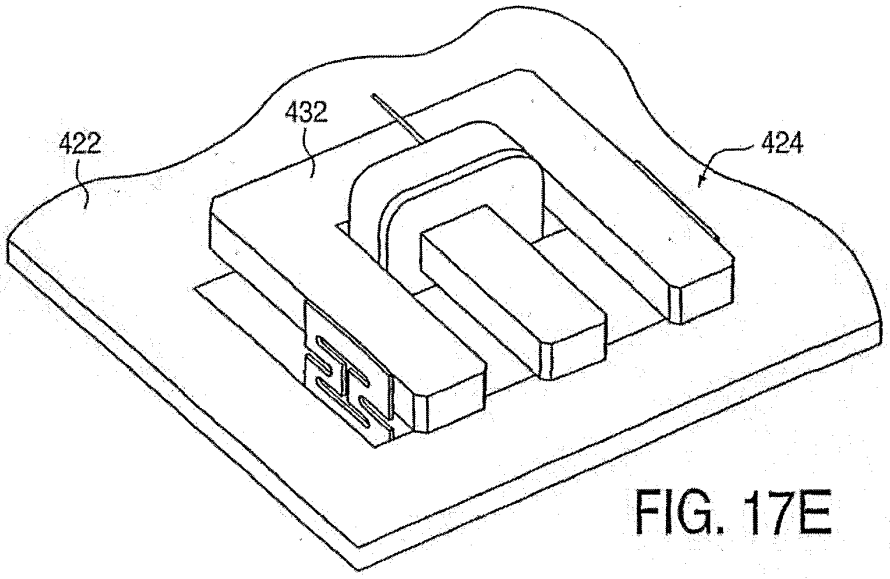
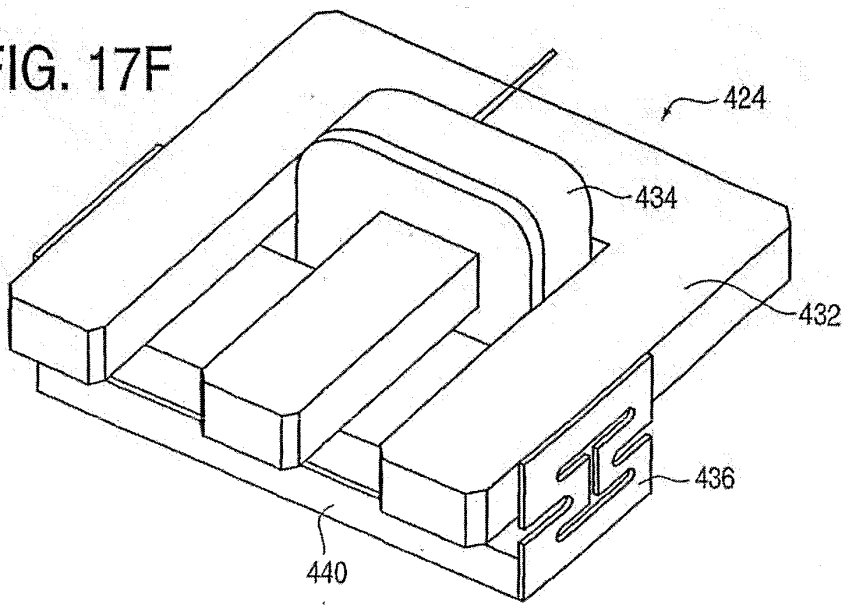


FIG. 17E

【図１７ｆ】

FIG. 17F



【図１７ｇ】

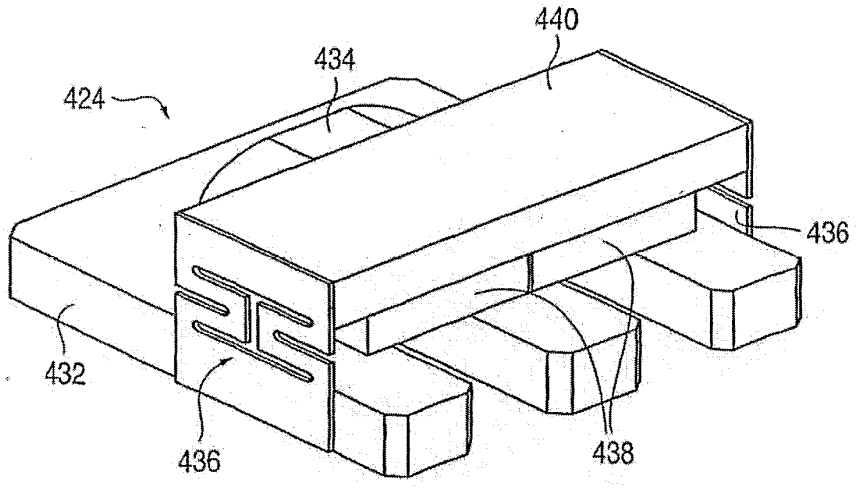


FIG. 17G

【図１８】

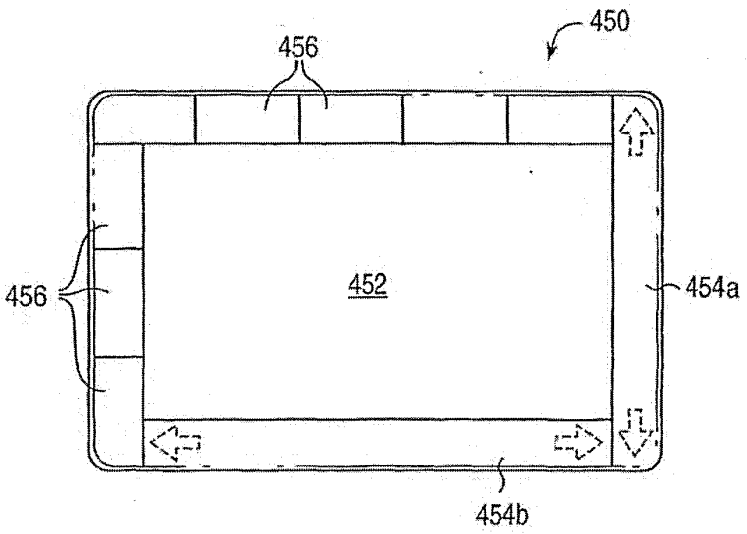


FIG. 18

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(74) Agent: RIEGEL, James, R. et al.; Immersion Corp., 801 Fox Lane, San Jose, CA 95131 (US).

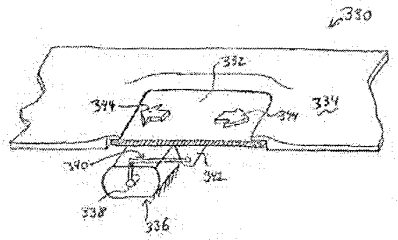
(81) Designated States (nationals): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW.

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Published:
— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HAPTIC INTERFACE FOR LAPTOP COMPUTERS AND OTHER PORTABLE DEVICES



(57) Abstract: A haptic feedback touch control is used to provide input to a computer. A touch input device includes a planar touch surface that provides position information to a computer based on a location of user contact. The computer can position a cursor in a displayed graphical environment based at least in part on the position information, or perform a different function. At least one actuator (330) is coupled to the touch input device and outputs a force to provide a sensation to the user. The actuator (330) can move the touchpad (332) laterally, or a separate surface member can be actuated. A flat R-wave actuator, piezoelectric actuator, or voice coil actuator can be used to provide forces. The touch input device can include multiple different regions to control different computer functions.

WO 02/073587 A1

HAPTIC INTERFACE FOR LAPTOP COMPUTERS AND OTHER PORTABLE DEVICES

BACKGROUND OF THE INVENTION

The present invention relates generally to the interfacing with computer and mechanical devices by a user, and more particularly to devices used to interface with computer systems and electronic devices and which provide haptic feedback to the user.

Humans interface with electronic and mechanical devices in a variety of applications, and the need for a more natural, easy-to-use, and informative interface is a constant concern. In the context of the present invention, humans interface with computer devices for a variety of applications. One such application is interacting with computer-generated environments such as games, simulations, and application programs. Computer input devices such as mice and trackballs are often used to control a cursor within a graphical environment and provide input in these applications.

In some interface devices, force feedback or tactile feedback is also provided to the user, collectively known herein as "haptic feedback." For example, haptic versions of joysticks, mice, gamepads, steering wheels, or other types of devices can output forces to the user based on events or interactions occurring within the graphical environment, such as in a game or other application program.

In portable computer or electronic devices, such as laptop computers, mice have typically too large a workspace to be practical. As a result, more compact devices such as trackballs are often used. Currently, a more popular device for portable computers are "touchpads," which are small rectangular, planar pads provided near the keyboard of the computer. The touchpad senses the location of a pointing object by any of a variety of sensing technologies, such as capacitive sensors or pressure sensors that detect pressure applied to the touchpad. The user contacts the touchpad most commonly with a fingertip and moves his or her finger on the pad to move a cursor displayed in the graphical environment. In other embodiments, the user can operate a stylus in conjunction with the touchpad by pressing the stylus tip on the touchpad and moving the stylus. Touchscreens are similar devices used to input information on a sensing pad layered on a display screen, and are used in such devices as personal digital assistants (PDA's) and other portable electronic devices.

One problem with existing touchpads and screens is that there is no haptic feedback provided to the user. The user of a touchpad is therefore not able to experience haptic sensations that assist and inform the user of targeting and other control tasks within the

graphical environment. The touchpads of the prior art also cannot take advantage of existing haptic enabled software running on the computer.

SUMMARY OF THE INVENTION

The present invention is directed to haptic feedback planar touch controls used to provide input to a computer system. The control can be a touchpad provided on a portable computer, or can be a touch screen found on a variety of devices. The haptic sensations output on the touch control enhance interactions and manipulations in a displayed graphical environment or when controlling an electronic device.

More specifically, the present invention relates to a haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control. The control includes a touch input device including an approximately planar touch surface operative to input a position signal to a processor of said computer based on a location of user contact on the touch surface. One or more actuators are coupled to the touch input device which can output a force to laterally move the touch input device approximately parallel to its surface to provide a haptic sensation to the user contacting it. The computer can position a cursor in a graphical environment displayed on a display device based on the position signal. The touch input device can be a separate touchpad or included as a touch screen.

In another embodiment, a haptic feedback touch control includes a touch input device including an approximately planar touch surface which inputs a position signal to a computer processor, a surface member located adjacent to the touch input device, where the user can contact the surface when pressing the touch input device, and an actuator coupled to the surface member. The actuator outputs a force on the surface member to provide a haptic sensation to the user. The surface member can be translated laterally, approximately in a plane parallel to the surface of the touch input device; for example, the surface member can be positioned over the touch input device and coextensive with the device surface, or the surface member can be positioned to a side of the touch input device such that the user touches the touch input device with one finger and touches the surface member with a different finger or palm. For example, the surface member can be positioned over a physical button that is located adjacent to said touch input device. Contact or inertial forces can be output on the surface member.

In another aspect of the present invention, an actuator providing a linear force output includes a ferromagnetic piece including a center pole located between two side poles, a coil wrapped around the center pole, a magnet adjacent to the center pole and side poles, and a backing plate coupled to the magnet, where the backing plate and magnet move with respect to

EX1002 - Page 1102

the ferromagnetic piece when current is flowed in the coil. Rollers can be positioned between the ferromagnetic piece and backing plate to allow the motion. A flexure can reduce the relative motion between plate and ferromagnetic piece in undesired directions and provide a spring centering force.

In another aspect, a haptic touch device includes a piezoelectric transducer coupled to a ground and including a metal diaphragm coupled to a ceramic element and a planar sensing element, such as a touchpad. A spacer is provided between the piezoelectric transducer and the planar sensing element, the metal diaphragm contacting the spacer. A spring element provides a spring restoring force to the planar sensing element.

In another aspect of the present invention, a method for providing haptic feedback to a touch input device includes receiving a position signal from the touch input device indicating a contact location on a surface where said user is pressing, and determining in which of a plurality of regions on the surface the contact location is positioned. An output force is associated with the user moving an object on or over the surface of the touch input device. A function can be associated with the region in which the contact location is positioned, such as rate control function of a value or moving a displayed cursor. The can be output when the user moves the object over a boundary to the contacted region from a different region of the touch input device.

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 are also inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

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

FIGURE 1 is a perspective view of a laptop computer device including a haptic touchpad of the present invention;

FIGURE 2 is a perspective view of a remote control device including a touchpad of the present invention;

FIGURE 3 is a top plan view of a haptic touchscreen embodiment of the present invention;

FIGURE 4 is a block diagram of a haptic system suitable for use in the present invention;

FIGURE 5 is a perspective view of one embodiment of an actuator assembly suitable for use in an inertial embodiment of the present invention;

FIGURE 6 is a perspective view of the actuator assembly of Fig. 5 coupled to a touchpad;

FIGURE 7 is a perspective view of a separate palm surface providing inertial tactile sensations adjacent to a touchpad;

FIGURE 8a is a perspective view of a piezoelectric transducer suitable for use in providing inertial sensations in the present invention;

FIGURE 8b is a side elevational view of a piezoelectric transducer and structure of the present invention suitable for providing haptic sensations with a touch device;

FIGURE 9 is a perspective view of one embodiment of a translating surface member driven by linear actuators;

FIGURE 10 is a top plan view of another embodiment of a translating surface member driven by a rotary actuator;

FIGURE 11 is a perspective view of another embodiment of a translating surface member driven by a voice coil actuator;

FIGURE 12 is a perspective view of an embodiment of a translating surface adjacent to a touchpad;

FIGURE 13 is a perspective view of an embodiment of a touchpad translated in one direction by a rotary actuator;

FIGURE 14 is a perspective view of an embodiment of a touchpad translated in two directions by rotary actuators;

FIGURES 15a and 15b are perspective views of a first embodiment of a flat E-core actuator of the present invention suitable for translating a touchpad or a separate surface;

FIGURE 15c is a side view of the actuator of Figs. 15a-15b;

FIGURE 15d is a perspective view of the actuator of Figs. 15a-15b coupled to a touchpad;

FIGURES 16a and 16b are top and bottom perspective views of another embodiment of a flat E-core actuator of the present invention;

FIGURES 17a-17b are perspective and top views of surface-mounted E-core actuators of the present invention;

FIGURES 17c-17g are perspective and side views of the E-core actuators of Figs. 17a-17b; and

FIGURE 18 is a top plan view of an example of a haptic touchpad of the present invention having different control regions.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIGURE 1 is a perspective view of a portable computer 10 including a haptic touchpad of the present invention. Computer 10 can be a portable or "laptop" computer that can be carried or otherwise transported by the user and may be powered by batteries or other portable energy source in addition to other more stationary power sources. Computer 10 preferably runs one or more host application programs with which a user is interacting via peripherals.

Computer 10 may include the various input and output devices as shown, including a display device 12 for outputting graphical images to the user, a keyboard 14 for providing character or toggle input from the user to the computer, and a touchpad 16 of the present invention. Display device 12 can be any of a variety of types of display devices; flat-panel displays are most common on portable computers. Display device 12 can display a graphical environment 18 based on application programs and/or operating systems that are running on the CPU of computer 10, such as a graphical user interface (GUI), that can include a cursor 20 that can be moved by user input, as well as windows 22, icons 24, and other graphical objects well known in GUI environments. Other graphical environments or images may also be displayed, e.g. a game, movie or other presentation, spreadsheet or other application program, etc.

Other devices may also be incorporated or coupled to the computer 10, such as storage devices (hard disk drive, DVD-ROM drive, etc.), network server or clients, game controllers, etc. In alternate embodiments, the computer 10 can take a wide variety of forms, including computing devices that rest on a tabletop or other surface, stand up arcade game machines, other portable devices or devices worn on the person, handheld or used with a single hand of the user, etc. For example, host computer 10 can be a video game console, personal computer, workstation, a television "set top box" or a "network computer", or other computing or electronic device.

Touchpad device 16 of the present invention preferably appears externally to be similar to the touchpads of the prior art. In many embodiments disclosed herein, such a pad 16 includes a planar, rectangular (or other shaped) smooth surface that can be positioned below the keyboard 14 on the housing of the computer 10, as shown, or may be positioned at other areas of the housing. When the user operates the computer 10, the user may conveniently place a fingertip or other object on the touchpad 16 and move the fingertip to correspondingly move cursor 20 in the graphical environment 18.

In operation, the touchpad 16 inputs coordinate data to the main microprocessor(s) of the computer 10 based on the sensed location of an object on (or near) the touchpad. As with many touchpads of the prior art, touchpad 16 can use capacitive, resistive, or a different type of sensing. Capacitive touchpads typically sense the location of an object on or near the surface of the touchpad based on capacitive coupling between capacitors in the touchpad and the object. Resistive touchpads are typically pressure-sensitive, where the pressure of a finger, stylus, or other object against the pad causes conductive layers, traces, switches, etc. in the pad to electrically connect. Some resistive or other types of touchpads can detect the amount of pressure applied by the user and can use the degree of pressure for proportional or variable input to the computer 10. Resistive touchpads typically are at least partially deformable, so that when a pressure is applied to a particular location, the conductors at that location are brought into electrical contact. Such deformability can be useful in the present invention since it can potentially amplify the magnitude of output forces such as pulses or vibrations on the touchpad as used in the present invention. Forces can be amplified if a tuned compliant suspension is provided between an actuator and the object that is moved. Capacitive touchpads and other types of touchpads that do not require significant contact pressure may be better suited for the present invention in some embodiments, since excessive pressure on the touchpad may in some cases interfere with the motion of the touchpad for haptic feedback. Other types of sensing technologies can also be used in the touchpad. Herein, the term "touchpad" preferably includes the surface of the touchpad 16 as well as any sensing apparatus included in the touchpad unit.

Touchpad 16 can operate similarly to existing touchpads, where the speed of the fingertip on the touchpad correlates to the distance that the cursor is moved in the graphical environment. For example, if the user moves his or her finger quickly across the pad, the cursor is moved a greater distance than if the user moves the fingertip more slowly. If the user's finger reaches the edge of the touchpad before the cursor reaches a desired destination in that direction, then the user can simply move his or her finger off the touchpad, reposition the finger away from the edge, and continue moving the cursor. This is an "indexing" function similar to lifting a mouse off a surface to change the offset between mouse position and cursor. Furthermore, many touchpads can be provided with particular regions that are each assigned to particular functions that can be unrelated to cursor positioning. Such an embodiment is described in greater detail below with respect to Fig. 18. In some embodiments the touchpad 16 may also allow a user to "tap" the touchpad (rapidly touch and remove the object from the pad) in a particular location to provide a command. For example, the user can tap or "double tap" the pad with a finger while the controlled cursor is over an icon to select that icon.

In the present invention, the touchpad 16 is provided with the ability to output haptic feedback such as tactile sensations to the user who is physically contacting the touchpad 16. Various embodiments detailing the structure of the haptic feedback touchpad are described in greater detail below. Some embodiments may move a device housing or separate moving surface, not the touchpad itself.

Using one or more actuators coupled to the touchpad 16 or an associated surface, a variety of haptic sensations can be output to the user who is contacting the touchpad (or housing or separate surface). For example, jolts, vibrations (varying or constant amplitude), and textures can be output. Forces output to the user can be at least in part based on the location of the finger on the pad or the state of a controlled object in the graphical environment of the host computer 10, and/or independent of finger position or object state. Such forces output to the user are considered "computer-controlled" since a microprocessor or other electronic controller is controlling the magnitude and/or direction of the force output of the actuator(s) using electronic signals.

In other embodiments, the touchpad 16 can be provided in a separate housing that is connected to a port of the computer 10 via a cable or via wireless transmission and which receives force information from and sends position information to the computer 10. For example, Universal Serial Bus (USB), Firewire, or a standard serial bus can connect such a touchpad to the computer 10.

One or more buttons 26 can also be provided on the housing of the computer 10 to be used in conjunction with the touchpad 16. The user's hands have easy access to the buttons, each of which may be pressed by the user to provide a distinct input signal to the host computer

12. Typically, each button 26 corresponds to a similar button found on a mouse input device, so that a left button can be used to select a graphical object (click or double click), a right button can bring up a context menu, etc. In some embodiments, one or more of the buttons 26 can be provided with tactile feedback.

Furthermore, in some embodiments, one or more moveable portions 28 of the housing of the computer device 10 can be included which is contacted by the user when the user operates the touchpad 16 and which can provide haptic feedback. Having a moveable portion of a housing for haptic feedback is described in U.S. Patent Nos. 6,184,868 and 6,088,019. In some embodiments, both the housing can provide haptic feedback (e.g., through the use of an eccentric rotating mass on a motor coupled to the housing) and the touchpad 16 can provide separate haptic feedback. This can allow the host to control two different tactile sensations simultaneously to the user; for example, a vibration of a low frequency can be conveyed through the housing to the user and a higher frequency vibration can be conveyed to the user through the touchpad 16. Each other button or other control provided with haptic feedback can also provide tactile feedback independently from the other controls.

The host application program(s) and/or operating system preferably displays graphical images of the environment on display device 12. The software and environment running on the host computer 12 may be of a wide variety. For example, the host application program can be a word processor, spreadsheet, movie, video or computer game, drawing program, operating system, graphical user interface, simulation, Web page or browser that implements HTML or VRML instructions, scientific analysis program, virtual reality training program or application, or other application program that utilizes input from the touchpad 16 and outputs force feedback commands to the touchpad 16. For example, many games and other application programs include force feedback functionality and may communicate with the touchpad 16 using a standard protocol/drivers such as I-Force®, FEELit®, or TouchSense™ available from Immersion Corporation of San Jose, California.

The touchpad 16 can include circuitry necessary to report control signals to the microprocessor of the host computer 10 and to process command signals from the host's microprocessor. For example, appropriate sensors (and related circuitry) are used to report the position of the user's finger on the touchpad 16. The touchpad device also includes circuitry that receives signals from the host and outputs tactile sensations in accordance with the host signals using one or more actuators. Some touchpads may be integrated with a printed circuit board (PCB) that includes some of these components and circuitry. In some embodiments, a separate, local microprocessor can be provided for the touchpad 16 to both report touchpad sensor data to the host and/or to carry out force commands received from the host, such commands including, for example, the type of haptic sensation and parameters describing the

commanded haptic sensation. Alternatively, the touchpad microprocessor can simply pass streamed data from the main processor to the actuators. The term "force information" can include both commands/parameters and/or streamed data. The touchpad microprocessor can implement haptic sensations independently after receiving a host command by controlling the touchpad actuators; or, the host processor can maintain a greater degree of control over the haptic sensations by controlling the actuators more directly. In other embodiments, logic circuitry such as state machines provided for the touchpad 16 can handle haptic sensations as directed by the host main processor. Architectures and control methods that can be used for reading sensor signals and providing haptic feedback for a device are described in greater detail in U.S. Patent No. 5,734,373.

In existing touchpad embodiments, such as those manufactured by Synaptics Corp., particular characteristics and features are provided. The standard surface material for a touchpad is textured Mylar, and typically any non-conductive object can be used on the touchpad surface and be detected, though textured surfaces are better when a user's finger is used to point. The touchpad can also sense through thin overlays. There is typically space available for the additional of haptic feedback components; for example, on a 40 x 60 touchpad, over half of the board can be available for haptic circuitry.

Many touchpads include a "palm check" feature, which allows the laptop to sense whether the user is contacting the touchpad with a finger or with a palm or other part of the hand. Since the user may only be resting his or her palm and not be intending to provide input, the palm check feature would ignore input that is determined to be provided by a user's palm. Basically, the palm check feature computes the contact area made by the conductive object (finger, palm, arm, etc.). If the contact area exceeds a certain threshold, the contact is rejected. This feature can be turned off in many embodiments.

FIGURE 2 is a perspective view of another embodiment of a device 30 which can include the active touchpad 16 of the present invention. The device can be a handheld remote control device 30, which the user grasps in one hand and manipulates controls to access the functions of an electronic device or appliance remotely by a user (such as a television, video cassette recorder or DVD player, audio/video receiver, Internet or network computer connected to a television, etc.). For example, several buttons 32 can be included on the remote control device 30 to manipulate functions of the controlled apparatus. A touchpad 16 can also be provided to allow the user to provide more sophisticated directional input. For example, a controlled apparatus may have a selection screen in which a cursor may be moved, and the touchpad 16 can be manipulated to control the cursor in two dimensions. The touchpad 16 includes the ability to output haptic sensations to the user as described herein, based on a

controlled value or event. For example, a volume level passing a mid-point or reaching a maximum level can cause a pulse to be output to the touchpad and to the user.

In one application, the controlled apparatus can be a computer system such as WebTV from Microsoft Corp. or other computing device which displays a graphical user interface and/or web pages accessed over a network such as the Internet. The user can control the direction of the cursor by moving a finger (or other object) on the touchpad 16. The cursor can be used to select and/or manipulate icons, windows, menu items, graphical buttons, slider bars, scroll bars, or other graphical objects in a graphical user interface or desktop interface. The cursor can also be used to select and/or manipulate graphical objects on a web page, such as links, images, buttons, etc. Other force sensations associated with graphical objects are described below with reference to Fig. 18.

FIGURE 3 is a top plan view of another computer device embodiment 50 that can include any of the embodiments of haptic devices of the present invention. Device 50 is in the form of a portable computer device such as "personal digital assistant" (PDA), a "pen-based" computer, "web pad," "electronic book", or similar device (collectively known as a "personal digital assistant" (PDA) herein). Those devices which allow a user to input information by touching a display screen or readout in some fashion are relevant to the present invention, as well as devices allowing button input. Such devices can include the Palm Pilot® from 3Com Corp. or similar products, pocket-sized computer devices from Casio, Hewlett-Packard, or other manufacturers, E-books, cellular phones or pagers having touch screens, laptop computers with touch screens, etc.

In one embodiment of a device 50, a display screen 52 positioned adjacent a housing 54 may cover a large portion of the surface of the computer device 50. Screen 52 is preferably a flat-panel display as is well known to those skilled in the art and can display text, images, animations, etc.; in some embodiments screen 52 is as functional as any personal computer screen. Display screen 52 can be a "touch screen" that includes sensors which allow the user to input information to the computer device 50 by physically contacting the screen 50 (i.e. it is another form of planar "touch device" similar to the touchpad 16 of Fig. 1). For example, a transparent sensor film can be overlaid on the screen 50, where the film can detect pressure from an object contacting the film. The sensor devices for implementing touch screens are well known to those skilled in the art.

The user can select graphically-displayed buttons or other graphical objects by pressing a finger or a stylus to the screen 52 at the exact location where the graphical object is displayed. Furthermore, some embodiments allow the user to "draw" or "write" on the screen by displaying graphical "ink" images 56 at locations where the user has pressed a tip of a stylus, such as stylus 57, or a finger or other object. Handwritten characters can be recognized by

software running on the device microprocessor as commands, data, or other input. In other embodiments, the user can provide input additionally or alternatively through voice recognition, where a microphone on the device inputs the user's voice which is translated to appropriate commands or data by software running on the device. Physical buttons 58 can also be included in the housing of the device 50 to provide particular commands to the device 50 when the buttons are pressed. Many PDA's are characterized by the lack of a standard keyboard for character input from the user; rather, an alternative input mode is used, such as using a stylus to draw characters on the screen, voice recognition, etc. However, some PDA's also include a fully-functional keyboard as well as a touch screen, where the keyboard is typically much smaller than a standard-sized keyboard. In yet other embodiments, standard-size laptop computers with standard keyboards may include flat-panel touch input display screens, and such screens (similar to screen 12 of Fig. 1) can be provided with haptic feedback according to the present invention.

In some embodiments of the present invention, the touch screen 52 may provide haptic feedback to the user similarly to the touchpad 16 described in previous embodiments. One or more actuators can be coupled to the touchscreen, or movable surfaces near the touchscreen, in a manner similar to the embodiments described below. The user can experience the haptic feedback through a finger or a held object such as a stylus 57 that is contacting the screen 52.

The touch screen 52 can be coupled to the housing 54 of the device 50 by one or more spring or compliant elements, such as helical springs, leaf springs, flexures, or compliant material (foam, rubber, etc.), to allow motion of the screen approximately along the z-axis, thereby providing haptic feedback. The screen can also be provided with flexures or other couplings allowing side-to-side (x and/or y) motion, similar to the appropriate embodiments described below.

FIGURE 4 is a block diagram illustrating a haptic feedback system suitable for use with any of the described embodiments of the present invention. The haptic feedback system includes a host computer system 74 and interface device 72

Host computer system 74 preferably includes a host microprocessor 100, a clock 102, a display screen 76, and an audio output device 104. The host computer also includes other well known components, such as random access memory (RAM), read-only memory (ROM), and input/output (I/O) electronics (not shown).

As described above, host computer 74 can be a personal computer such as a laptop computer, and may operate under any well-known operating system. Alternatively, host computer system 74 can be one of a variety of home video game console systems commonly connected to a television set or other display, such as systems available from Nintendo, Sega,

Sony, or Microsoft. In other embodiments, host computer system 74 can be an appliance, "set top box", or other electronic device to which the user can provide input. Computer 74 can also be a portable, hand-held computer such as a PDA, or can be a vehicle computer, stand-up arcade game, workstation, etc.

Host computer 74 preferably implements a host application program with which a user is interacting via interface device 72 which includes haptic feedback functionality. For example, the host application program can be a video game, word processor or spreadsheet, Web page or browser that implements HTML or VRML instructions, scientific analysis program, movie player, virtual reality training program or application, or other application program that may utilize input of mouse 12 and which outputs haptic feedback commands to the device 72. Herein, for simplicity, operating systems such as Windows™, MS-DOS, MacOS, Unix, Palm OS, etc. are also referred to as "application programs." Herein, computer 74 may be referred as providing a "graphical environment," which can be a graphical user interface, game, simulation, or other visual environment and can include graphical objects such as icons, windows, game objects, etc. Suitable software drivers which interface such software with computer input/output (I/O) devices are available from Immersion Corporation of San Jose, California.

Display device 76 can be included in host computer 74 and can be a standard display screen (LCD, CRT, plasma, flat panel, etc.), 3-D goggles, or any other visual output device. Audio output device 104, such as speakers, is preferably coupled to host microprocessor 100 to provide sound output to user. Other types of peripherals can also be coupled to host processor 100, such as storage devices (hard disk drive, CD ROM drive, floppy disk drive, etc.) other input and output devices.

Interface device 72 is coupled to the computer 74 by a bus 80, which communicates signals between device 72 and computer 74 and may also, in some embodiments, provide power to the device 72. In other embodiments, signals can be sent between device 72 and computer 74 by wireless transmission/reception. In some embodiments, the power for the actuator can be supplemented or solely supplied by a power storage device provided on the device, such as a capacitor or one or more batteries. The bus 80 can be bi-directional to send signals in either direction between host 74 and device 72. Bus 80 can be a serial interface bus, such as an RS232 serial interface, RS-422, Universal Serial Bus (USB), MIDI, or other protocols well known to those skilled in the art; or a parallel bus or wireless link.

Device 72 may be a separate device from host 74 with its own housing, or may be integrated with the host computer housing, as in the laptop computer of Fig. 1. Device 72 can include or be associated with a dedicated local processor 110. Processor 110 is considered local to device 12, where "local" herein refers to processor 110 being a separate processor from any

host processors in host computer system 14. "Local" also may refer to processor 110 being dedicated to haptic feedback and sensor I/O of device 12. Processor 110 can be provided with software instructions (e.g., firmware) to wait for commands or requests from computer host 74, decode the command or request, and handle/control input and output signals according to the command or request. In addition, processor 110 can operate independently of host computer 74 by reading sensor signals and calculating appropriate forces from those sensor signals, time signals, and stored or relayed instructions selected in accordance with a host command. Suitable microprocessors for use as local processor 110 include lower-end microprocessors as well as more sophisticated force feedback processors such as the Immersion Touchsense Processor. Processor 110 can include one microprocessor chip, multiple processors and/or co-processor chips, digital signal processor (DSP) capability, and/or logic, state machines, an ASIC, etc.

Processor 110 can receive signals from sensor 112 and provide signals to actuator 88 in accordance with instructions provided by host computer 74 over bus 80. For example, in a local control embodiment, host computer 74 provides high level supervisory commands to processor 110 over bus 20 (such as a command identifier and one or more parameters characterizing the tactile sensation), and processor 110 decodes the commands and manages low level force control loops to sensors and the actuator in accordance with the high level commands and independently of the host computer 74. This operation is described in greater detail in US Patent 5,734,373. In the host control loop, force commands are output from the host computer to processor 110 and instruct the processor to output a force or force sensation having specified characteristics. The local processor 110 reports data to the host computer, such as locative data that describes the position of the device in one or more provided degrees of freedom. The data can also describe the states of buttons, switches, etc. The host computer uses the locative data to update executed programs. In the local control loop, actuator signals are provided from the processor 110 to an actuator 88 and sensor signals are provided from the sensor 112 and other input devices 118 to the processor 110. Herein, the term "tactile sensation" refers to either a single force or a sequence of forces output by the actuator 18 which provide a sensation to the user. For example, vibrations, a single jolt, or a texture sensation are all considered tactile sensations. The processor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions. The processor may use sensor signals in the local determination of forces to be output on the user object, as well as reporting locative data derived from the sensor signals to the host computer.

In yet other embodiments, other hardware instead of processor 110 can be provided locally to device 72 to provide functionality similar to processor 110. For example, a hardware state machine incorporating fixed logic can be used to provide signals to the actuator 88 and receive sensor signals from sensors 112, and to output tactile signals.

In a different, host-controlled embodiment, host computer 74 can provide low-level force commands over bus 20, which are directly transmitted to the actuator 18 via processor 110 or other circuitry if there is no processor 110. Host computer 14 thus directly controls and processes all signals to and from the device 72, e.g. the host computer directly controls the forces output by actuator 88 and directly receives sensor signals from sensor 112 and input devices 118. Other embodiments may employ a "hybrid" organization where some types of forces (e.g. closed loop effects) are controlled purely by the local microprocessor, while other types of effects (e.g., open loop effects) may be controlled by the host.

Local memory 122, such as RAM and/or ROM, is preferably coupled to processor 110 in device 72 to store instructions for processor 110 and store temporary and other data. Memory 122 can also or alternatively be included on the processor 110. In addition, a local clock 124 can be coupled to the processor 110 to provide timing data.

Sensors 112 sense the position or motion (e.g. an object on a touchpad) in desired degrees of freedom and provides signals to processor 110 (or host 74) including information representative of the position or motion. Sensors suitable for detecting motion include capacitive or resistive sensors in a touchpad, contact sensors in a touchscreen, etc. Other types of sensors can also be used. Optional sensor interface 114 can be used to convert sensor signals to signals that can be interpreted by the processor 110 and/or host computer system 14.

Actuator(s) 88 transmit forces to the housing, manipulandum, buttons, or other portion of the device 72 in response to signals received from processor 110 and/or host computer 14. Device 72 preferably includes one or more actuators which are operative to produce forces on the device 72 (or a component thereof) and haptic sensations to the user. The actuator(s) are "computer-controlled", e.g., the force output from the actuators is ultimately controlled by signals originating from a controller such as a microprocessor, ASIC, etc. Many types of actuators can be used, including rotary DC motors, voice coil actuators, moving magnet actuators, E core actuators, pneumatic/hydraulic actuators, solenoids, speaker voice coils, piezoelectric actuators, passive actuators (brakes), etc. Some preferred actuator types are described below. Actuator interface 116 can be optionally connected between actuator 88 and processor 110 to convert signals from processor 110 into signals appropriate to drive actuator 88. Interface 116 can include power amplifiers, switches, digital to analog controllers (DACs), analog to digital controllers (ADCs), and other components, as is well known to those skilled in the art.

In some of the implementations herein, the actuator has the ability to apply short duration force sensation on the housing or manipulandum of the device, or via moving an inertial mass. This short duration force sensation can be described as a "pulse." The "pulse" can be directed substantially along a particular direction in some embodiments. In some

embodiments, the magnitude of the "pulse" can be controlled; the sense of the "pulse" can be controlled, either positive or negative biased; a "periodic force sensation" can be applied and can have a magnitude and a frequency, e.g. the periodic sensation can be selectable among a sine wave, square wave, saw-toothed-up wave, saw-toothed-down, and triangle wave; an envelope can be applied to the period signal, allowing for variation in magnitude over time. The wave forms can be "streamed" from the host to the device, , or can be conveyed through high level commands that include parameters such as magnitude, frequency, and duration.

Other input devices 118 can be included in device 72 and send input signals to processor 110 or to host 74 when manipulated by the user. Such input devices include buttons, dials, switches, scroll wheels, knobs, or other controls or mechanisms. Power supply 120 can optionally be included in device 72 coupled to actuator interface 116 and/or actuator 18 to provide electrical power to the actuator. Alternatively, power can be drawn from a power supply separate from device 72, or power can be received across bus 80. Also, received power can be stored and regulated by device 72 (and/or host 74) and thus used when needed to drive actuator 88 or used in a supplementary fashion.

The interface device 12 can be any of a variety of types; some embodiments are described further below. The touchpads or touchscreen described herein can be provided on a variety of types of devices, such as gamepads, joysticks, steering wheels, touchpads, spherical controllers, finger pads, knobs, track balls, remote control device, cell phone, personal digital assistant, etc.

Specific Embodiments

The present invention presents a variety of embodiments in which haptic feedback is provided to a user of a laptop computer or other portable computing device, and/or to the user of any computing device having a touchpad or similar input device.

Some embodiments are based on displacing the skin of a user's finger when it is in contact with a touchpad. These embodiments deliver high fidelity sensations while offering a good correlation between input and output right at the user's fingertip. Actuator and linkage solutions are described to drive any of the translation embodiments. Other embodiments are based on the stimulation of palm surfaces of the user that are normally in contact with the laptop computer 10. These surfaces can provide haptic sensations based on inertially coupled forces or translation of the palm surfaces. Translations of surfaces in plane with the upper surface of the touchpad or laptop (i.e. in the X and/or Y axes) are as effective at conveying haptic information as vibrations or displacements in the Z axis (those normal to the touchpad or

laptop upper surface). This can be important when the volumetric constraints of a laptop are considered.

In many of the embodiments described herein, it is also advantageous that contact of the user is detected by a touch input device. Since haptic feedback need only be output when the user is contacting the touch device, this detection allows haptic feedback to be stopped (actuators "turned off") when no objects are contacting the touch input device. This feature can conserve battery power for portable devices. If a local touch device microprocessor (or similar circuitry) is being used in the computer, such a microprocessor can turn off actuator output when no user contact is sensed, thus alleviating the host processor of additional computational burden until touch is again detected, when the actuator output is returned.

In many preferred embodiments, haptics are added to a laptop computer or other device in a way that does not force the user to relearn how to control the laptop or force the manufacturer to stretch design and manufacturing too far from existing designs to provide the haptic content. For example, in laptop embodiments, as the user moves his or her finger across the touchpad, a cursor displayed on the laptop screen is correspondingly moved. Haptic effects can be output on the touchpad or other laptop component contacted by the user when the cursor intersects with a graphical object or area, when an event occurs, etc. In other applications, haptic effects can be output when events or interactions occur in a game or other application running on the laptop. Many types of actuators, sensors, linkages, amplification transmissions, etc. can be used with the present invention.

A touchpad surface, as manufactured currently, typically is coupled to a printed circuit board (PCB) that includes necessary electronics and standard connections for connecting and operating the touchpad in a laptop. Thus, when forces are applied to the touchpad, they are also applied to the PCB that is often directly coupled to the touchpad, e.g. underneath the touchpad.

The embodiments herein are designed with particular guidelines and characteristics. For example, the particular haptic experiences that feel compelling in a certain embodiment, the location where the tactile content is focused or located physically, the spatial correlation of the haptic feedback with the pointing of the user's finger on the touchpad, e.g. the feedback can be right under the finger , or originate somewhere in the case/housing of the laptop, the required force strength and power for compelling feedback, the way the user interacts with the device and effect on quality and content of the feedback (angle of finger contact, etc), and which actuators and mechanisms that can fit into the laptop form factor/housing are most desirable.

Preferably, existing haptic feedback software and drivers can be used with the embodiments described herein, such as TouchSense software from Immersion Corp. A

standardized module, such as a particular touchpad, that works for many different types of products is desirable, such as PDAs, laptops, cell phones, and remote controls.

The focus of these inventive embodiments is primarily on tactile feedback implementations, not kinesthetic force feedback embodiments. As described herein, there are two basic classes of tactile feedback as applied to the present invention: inertial haptic feedback and moving contact haptic feedback. Inertial feedback is generated using inertially coupled vibrations and is based on moving an inertial mass that is coupled to the housing/user through a compliant flexure, where the mass motions cause inertial vibrations in a surface contacted by the user. Moving contact feedback relates to directly moving a surface or member, with respect to an earth ground, against the user and usually is generated by creating small displacements of the user's skin.

The distinction between inertial and moving contact feedback can be made in terms of the actual mechanism used to provide information to the user. Both inertial and tactile stimulation cause displacement of the hand or finger tissue; the inertial feedback is coupled through some enclosure by the transmissibility of that enclosure and the compliance of whatever holds the enclosure. Moving contact feedback refers to a mechanism that is more direct in how it stimulates the user's tissue. Examples would be tactile dots or surfaces that shear the skin of the finger to cause sensation by locally deforming the finger or palm tissue. This distinction is made for the purposes of classifying two types of embodiments described below: inertial and surface translation.

A novel actuator, referred to as Flat-E herein, is described below and can be used in all of the embodiments herein and represents a class of very low profile, power efficient, high performance, planar actuators. A Flat-E actuator can achieve acceptable performance levels and approach the limited volume and form factor required for laptop and other device applications.

Inertial Embodiments

These embodiments move an inertial mass to cause inertial haptic feedback to the user, which is typically transmitted through an enclosure or mechanism such as a housing or other surface. In many cases, inertial mass does not impact any surfaces in its travel, although such impacts can alternatively be used to provide additional haptic effects.

FIGURE 5 is a perspective view of one embodiment 150 of an actuator assembly that can be used to provide inertial haptic sensations for touchpads and housings of devices of the present invention. Actuator assembly 150 includes a grounded flexure 160 and an actuator 155.

The flexure 160 can be a single, unitary piece made of a material such as polypropylene plastic ("living hinge" material) or other flexible material. Flexure 160 can be grounded to the housing of the device 12, for example, at portion 161.

Actuator 155 is coupled to the flexure 160. The housing of the actuator is coupled to a receptacle portion 162 of the flexure 160 which houses the actuator 155 as shown. A rotating shaft 164 of the actuator is coupled to the flexure 160 in a bore 165 of the flexure 160 and is rigidly coupled to a central rotating member 170. The rotating shaft 164 of the actuator is rotated about an axis A which also rotates member 170 about axis A. Rotating member 170 is coupled to a first portion 172a of an angled member 171 by a flex joint 174. The flex joint 174 is made very thin in the dimension it is to flex so that the flex joint 174 will bend when the rotating portion 170 moves the first portion 172a approximately linearly. The first portion 172a is coupled to the grounded portion 180 of the flexure by a flex joint 178 and the first portion 172a is coupled to a second portion 172b of the angled member by flex joint 182. The second portion 172b, in turn, is coupled at its other end to the receptacle portion 162 of the flexure by a flex joint 184.

The angled member 171 that includes first portion 172a and second portion 172b moves linearly along the x-axis as shown by arrow 176. In actuality, the portions 172a and 172b move only approximately linearly. When the flexure is in its origin position (rest position), the portions 172a and 172b are preferably angled as shown with respect to their lengthwise axes. This allows the rotating member 170 to push or pull the angled member 171 along either direction as shown by arrow 176.

The actuator 155 is operated in only a fraction of its rotational range when driving the rotating member 170 in two directions, allowing high bandwidth operation and high frequencies of pulses or vibrations to be output. A flex joint 192 is provided in the flexure portion between the receptacle portion 162 and the grounded portion 180. The flex joint 192 allows the receptacle portion 162 (as well as the actuator 155, rotating member 170, and second portion 172b) to move approximately linearly in the z-axis in response to motion of the portions 172a and 172b. A flex joint 190 is provided in the first portion 172a of the angled member 171 to allow the flexing about flex joint 192 in the z-direction to more easily occur.

By quickly changing the rotation direction of the actuator shaft 164, the actuator/receptacle can be made to oscillate along the z-axis and create a vibration on the housing with the actuator 155 acting as an inertial mass. In addition, the flex joints included in flexure 160, such as flex joint 192, act as spring members to provide a restoring force toward the origin position (rest position) of the actuator 155 and receptacle portion 172. In some embodiments, the stops can be included in the flexure 160 to limit the motion of receptacle portion 122 and actuator 155.

Other embodiments can provide other types of actuator assemblies to provide inertial sensations, such as a flexure that moves a separate inertial mass instead of the actuator itself. Or, an eccentric mass coupled to a rotating shaft of an actuator can be oscillated to provide rotational inertial tactile sensations to the housing. The eccentric mass can be unidirectionally driven or bidirectionally driven. Other types of actuator assemblies may also be used, such as a linear voice coil actuator, solenoid, moving magnet actuator, etc.

In one embodiment, an actuator assembly such as described above may be coupled to any of various locations of a laptop housing or other device housing and used to vibrate parts of the housing, relying on the transmission of vibrations through the product housing by the remotely mounted actuator module. The actuator assembly can be attached to different areas of the laptop housing or components to provide inertial haptic feedback when the inertial mass is oscillated.

The experience of the user may vary depending on the precise location of the actuator assembly on the laptop and with different tactile effects that are output. Locations for the coupling of the actuator assembly include the housing bottom, side, or front, a surface engaged by the user's palm when operating the device, an area adjacent to the touchpad or touchscreen, or coupled to the touchpad or touchscreen. An effective location may be the touchpad itself (e.g. coupling the actuator assembly to the bottom of the touchpad). In some embodiments, if the touchpad is rectangular, more compliance may be achieved along the long axis of the touchpad.

In general, haptic content is received by the user over a limited frequency range by attaching the actuator assembly to a location on the laptop. A particular location most effective for transmitting vibrations can be determined by experimentation, for example.

In many cases, the output of several types of haptic effects can be faint and muddy to the user, and effects having predominantly higher frequencies may be more perceptible. One effective tactile effect for this embodiment is a relatively high frequency "ringing" effect. Sympathetic vibrations in the laptop case and the touchpad may amplify these vibrations. An actuator designed to resonate at a certain ideal frequency may be used to present a wide spectrum of frequencies by amplitude modulation techniques. For example, a compelling 25 Hz square wave can be generated by modulating a 250 Hz natural frequency generated by a tuned resonant actuator such as a large piezo ceramic resonator (see Figs. 8a-8b). Such modulation schemes may rely on the actuator being tuned to the environment it lives in and the object it must drive. Some type of vibration isolation system can be used in some embodiments to keep the energy confined to the haptic module as opposed to allowing the energy to dissipate off into sympathetic modes in other portions of the laptop computer or other device.

EX1002 - Page 1119

FIGURE 6 is a perspective view of another embodiment, in which a touchpad module can be suspended in a compliant support structure and can be coupled to a harmonic source and vibrated along the Z-axis. In this example, a touchpad 200 can be moved with an actuator assembly 202 that moves the touchpad surface in the Z-axis, perpendicular to the surface of the touchpad. The touchpad can be coupled to the laptop housing 204 by one or more layers or supports of foam, rubber, or other compliant material, where a strip 206 of foam provided around the perimeter of the touchpad between the touchpad 200 and the housing 204 as shown in Fig. 6. The actuator assembly 202 can be coupled to the bottom of the touchpad assembly (or to another location) so that when the inertial mass is oscillated, the oscillations transfer to the touchpad and allow it move in the Z-direction with respect to the laptop housing 204. For example, the actuator assembly can be bonded directly to the bottom of the touchpad PCB. A floating assembly of a touchpad and a bezel (surface surrounding the touchpad) can alternatively be moved, as opposed to just moving the touchpad module in the Z-axis.

In another embodiment, a stand-alone touchpad device can be used, where the touchpad is housed in a separate housing and communicates with the laptop or other device via wires or transmissions. In one embodiment, the stand-alone touchpad device can be attached to a palm pad (or other member), with the actuator assembly coupled to the pad. When the inertial mass of the actuator assembly is oscillated, the inertial sensations are transmitted through the member to the touchpad, i.e. this effectively provides inertial coupling from the actuator assembly to the touchpad surface. A foam layer (or other compliant layer) can be coupled between the pad and ground to provide compliance and allow the pad and touchpad to move inertially. This embodiment may feel more compelling than the embodiments in which the actuator assembly is mounted to the laptop near or on the built-in touchpad, possibly due to the compliance of the foam which can allow stronger sensations to be output.

The entire touchpad can be provided with haptic sensations as a single unitary member, or, in other embodiments, individually-moving portions of the pad can each be provided with its own haptic feedback actuator and related transmissions so that haptic sensations can be provided for only a particular portion. For example, some embodiments may include a touchpad having different portions that may be flexed or otherwise moved with respect to other portions of the touchpad.

In another embodiment, the surface around or adjacent to the touchpad is coupled to harmonic vibration source (e.g., actuator assembly) and vibrates in one or more axes. For example, palm rest surfaces may be driven by an inertial actuator assembly housed in the laptop. FIGURE 7 is a perspective view of one example of an inertially-driven palm rest surface. A laptop computer 210 includes a touchpad 212 that functions like a typical touchpad. A palm rest surface 214 is positioned adjacent to the touchpad 212, where the surface 214 can

be attached to the laptop housing on a layer of resilient open cell foam or other compliant material. In some embodiments, the surface 214 can be textured with divots and/or bumps to allow a stronger contact by the user to the surface. An actuator assembly 216 is coupled to the palm rest surface 214; in the embodiment shown, the assembly 216 is coupled to the underside of the surface 214. The assembly can be any of the actuator assemblies described above. For example, the actuator assembly 216 can provide z-axis oscillations to the palm rest surface 214.

The user preferably rests a palm and/or some fingers on the palm rest surface 214 while the user is using the touchpad 212 with a pointing finger(s). Thus, the user is able to feel haptic sensations through the palm rest surface while operating the touchpad. Alternatively, one hand of the user is used to point and operate the touchpad, while the other hand rests on the palm surface 214 and senses haptic feedback. The palm surfaces are implemented as practically unavoidable contact surfaces and consequently a user is not likely to miss very many haptic events while using the touchpad. In some embodiments, how hard the user rests the palms on the surface can make a slight difference in perceived magnitude over the useful bandwidth, and may be a result of stiffness and mass of the particular device used. The stiffness of the coupling of the palm surface with the housing can be adjusted for a particular feel in different embodiments.

In a related embodiment, the actuator assembly can be mounted in different areas. For example, the actuator assembly can be attached to the bottom of an extension of a palm rest surface made of textured material mounted on a layer of resilient open cell foam or other compliant material.

In other embodiments, the palm surface can be translated in the X and/or Y directions, similarly to the touchpad translation described below. The inertial actuator assembly could be used to force the translation, or a different type of actuator, e.g. high actuator authority and fairly high stiffness in the translation mode to avoid unintentional hard stop limiting distortion, etc. The translating palm surface can be suitable for a flat actuator so that the assembly can be integrated into the laptop housing; flat actuators are described below.

FIGURE 8a is a perspective view of an actuator that can be used in another embodiment of an inertial haptic feedback device of the present invention. In this embodiment, a higher frequency mechanical oscillator, mechanically coupled to the touchpad, is modulated. One example of such an implementation may include a large-diameter commercially available thin piezoelectric transducer 230, e.g., 60mm in diameter with natural frequencies of 300 to 400 Hz when supported peripherally. The piezoelectric transducer preferably includes a thin diaphragm (sheet) of metal 231. One embodiment may include an added mass 232 at the ceramic center of the piezo diaphragm in order to add inertial mass and lower the natural frequency to achieve stronger inertial tactile sensations from the oscillating mass. The outer periphery of transducer

230 can be grounded and the mass 232 can oscillate normal to the disc surface to create inertial haptic sensations to the housing to which the transducer is attached.

Actuator 230 can function as a harmonic oscillator that runs at a relatively high frequency that transmits sensations to the hand or part of the laptop to which it is attached. Amplitude modulation (envelope control) may be used to produce a wider haptic spectrum than the single fundamental drum mode. Large diameter piezo drivers are available, for example, from Kingstate of Taiwan. Differently sized discs can also be used.

To provide the desired haptic sensations, a large piezo transducer or "buzzer" should provide large sustainable displacements (accelerations) of the mass and the carrier frequency (the frequency at which it oscillates) should be modulated with the haptic signal. Some electronics may be needed to operate this type of actuator. A high voltage supply can be generated from 5 volts. An oscillation circuit, e.g., self exciting, can drive the element. There can be a gating feature to start and stop the oscillation as well as a proportional control to allow modulation of the amplitude of the output. An all-digital implementation may be provided by gating the oscillator on and off.

FIGURE 8b is a side elevational view of another embodiment 234 of a piezoelectric transducer providing haptic feedback, where the transducer applies (non-inertial) vibrations directly to the touchpad (or touchscreen) along the z-axis. A housing 236 of the laptop or other device can include bezels which overlay a touchpad member 238, which the user physically contacts to provide input to a computer or processor. The touchpad member 238 can include the required electronics to interface the touchpad with other electronic components. The touchpad member 238 can rest on a spacer 240 having a particular mass chosen to allow efficient haptic output. The spacer 240 rests on the edge of a piezo metal diaphragm 231, which is part of the piezo transducer, and where an electrical lead 241 is coupled between the diaphragm 231 and a signal source 246. The piezo ceramic element 242, also part of the piezo transducer, is coupled to the metal diaphragm 231 and an electrical lead 243 is coupled between the element 242 and the signal source 246. A conductive electrode is plated on the ceramic element 242. A contact pad 248 is positioned between the element 342 and a bottom housing 250, where the contact pad is rigidly coupled to both ceramic element 242 and housing 250. The contact pad 248 is made small so that the diaphragm 231 will have increased bending, resulting in greater acceleration and stronger haptic effects. The bottom housing 250 can include a printed circuit board (PCB), for example. One or more preloaded spring elements 252 couple the touchpad member 238 to the bottom housing 250, e.g. leaf springs, helical springs, etc.

In operation, the piezo transducer moves along the z-axis when an oscillating current from signal source 246 is flowed through the diaphragm 231 and the ceramic element 242.

Thus, spacer 240 is provided only at the edges of the diaphragm 231 to allow the inner portion of the diaphragm and the ceramic element 242 to move, and the ceramic element pushes against the bottom housing 250, causing the diaphragm 231 to push against the spacer 240, which in turn pushes against the touchpad element 238. This pushes the touchpad element up, and the spring elements 252 provide a spring return force on the touchpad so that it will return to its neutral position. When the piezo transducer similarly moves in the opposite direction, as directed by the oscillating signal, this moves the touchpad element 238 down toward the bottom housing 250. The touchpad element thus oscillates along the z-axis and provides haptic sensations to the user contacting the touchpad element.

In some embodiments, the components of the touchpad embodiment 234 can be chosen to provide more effective haptic sensations. For example, if the piezo transducer oscillates at close to a natural frequency of the mechanical system (including the transducer itself), then stronger forces and more effective haptic sensations can be output. The natural frequency of this moving mechanical system can be approximately expressed as the square root of the expression k1 plus k2 divided by m, as shown below:

$$fn = \sqrt{(k1 + k2 / m)}$$

where fn is the natural frequency, k1 is the spring constant of the metal diaphragm 231 of the piezo transducer, k2 is the spring constant of the spring elements 252, and m is the total mass of the spacer 240, the touchpad 238, and the parts of the suspension attached to the touchpad. This mass, as well as the spring constants, can be selected to provide a desirable low natural frequency, such as about 120 Hz or less, which tends to cause effective haptic sensations. The spacer 240 can allow multiple piezo transducers, e.g. positioned side by side, to be positioned against the bottom housing 250, so that the multiple transducers can be driven in unison for stronger haptic effects or at different times to provide sensations at particular locations of the touchpad element 238.

One way to provide the drive signal is to provide an initial oscillating carrier signal at or near the natural frequency fn, modulate the carrier signal with an effect envelope, if applicable (e.g. shape the amplitude to a desired configuration to provide a desired frequency or effect), and drive an amplifier with the modulated signal, which in turn drives the piezo transducer. A sine wave carrier signal, as opposed to square wave or other types, used in such an embodiment tends to produce quieter haptic effects in the described embodiment of Fig. 8b, which is often more desirable.

In an alternate embodiment, the piezoelectric transducer and spacer can be reversed in orientation so that the spacer 240 contacts the bottom housing 250, the diaphragm 231 rests on the spacer 240, the ceramic element 242 is positioned above the diaphragm, and the ceramic

element directly impacts the touchpad element 238 or a pad coupled to the touchpad member when it is oscillated by the driving signal. In yet other embodiments, the ceramic element can be directly coupled to the touchpad element, but in general less strong and effective haptic effects are the result.

Surface Translation Embodiments

These embodiments translate a surface that is in contact with the user to provide haptic feedback to the user. The user feels the translating surface in shear with his or her skin, creating an immediate sensation. This type of haptic feedback is based on either surface motion in-plane without interactions with fixed surfaces or relative motion between adjacent surfaces that are in contact with the users finger or hand. Both translation of a surface in contact with or adjacent to the touchpad module surface (Figs. 9-12), as well as displacement of the touchpad surface itself (Figs. 13-14) are embodiments described below, as well as actuators that may be used for either application (Figs. 15-17). Moving-surface inventions described in U.S. Patent No. 5,184,868 can also be applied.

Small (< 1 mm) displacements between adjacent surfaces provide good signal transmission into finger tissue. Enhanced surfaces may have a physical surface texture (bumps, roughness, etc.) and can be shaped to engage the user for any position or orientation. In some embodiments, small lateral translations (displacements under the finger tip between .25mm to 0.5mm) can be more effective than remote inertial vibrations or even out-of-plane (z-axis) vibrations right under the touchpad, e.g., inertial coupling can have a more remote and disconnected feeling in some embodiments.

Separate Surface Translation

Displacing a separate surface member positioned on top of a touchpad module is very effective at providing well-correlated feedback. The feedback feels sufficiently synchronized that clear surfaces may be translated above visual displays, as in PDAs or touch screens. Translation of other surfaces to the side or otherwise adjacent to the touchpad can also be performed in other embodiments.

FIGURE 9 is a perspective view of a first separate surface translation embodiment 250 in which a separate thin surface that is in sliding contact with the touchpad module is moved laterally under the finger. A translating surface member ("surface") 252 is positioned on top of and covering the fixed touchpad 254. Extension members 256a and 256b which are coupled to the translating surface 252 can be extended approximately perpendicularly in the x- and y- directions away from the touchpad 254. An actuator 258a and 258b can be coupled to each

associated extension member 256a and 256b, respectively. In the described embodiment, the actuators 258 are linear actuators outputting a linear force on the associated extension member 256, thereby moving the translating surface in the direction of the output force. For example, the actuators can be "E" core actuators. The two pole magnet 259 is not shown on the actuator 258b to reveal the coil 260 under the ferromagnetic piece 382.

The sliding surface 252 can be any of a variety of stiff or substantially stiff materials; for example, Kapton (polyamid) flexible printed circuit board material can be used. The extension members 256 can incorporate a stiffener section to prevent buckling. The sliding surface 252 can be a textured surface that provides a friction force to engage the user skin tissue in contact with the surface. A region on the top of the moving surface 252 can include the texture having sufficient surface roughness to provide purchase on the skin without feeling rough to touch. On the underside of the moving surface, a low friction coating can be included to promote sliding between surface 252 and touchpad 254. This underside component can be very thin, for example, less than 0.010 inches (.25 mm) thick.

The user points to and contacts the moving surface 252 just as if it were the touchpad 254 itself. The surface 252 is made thin enough so that the touchpad 254 can detect all the contact of the user to the surface 252 as if the user were touching the location of the touchpad directly underneath the location touched on the surface 252.

In some embodiments, the actuators can be located relatively far from the moving surface (e.g., >10cm) and in these cases the stiffer extension members 256 may need to transmit tension and compression with as little friction or out-of-plane movement as possible. Fiber laminations of glass or carbon can perform this function, for example.

In some moving magnet actuator embodiments, thin rare earth magnetic pieces can be laminated to the moving surface 252 to act as the moving magnets. A high level of integration can be achieved, for example, if the moving magnet pieces are on the order of < 1 mm in thickness and the "E" core and coil are located below the distal segments of the extensions 256, e.g., mounted directly to the touchpad PCB itself. The coil wires can be soldered directly to the touchpad PCB.

FIGURE 10 is a top plan view of another translating surface embodiment 270 in which a separate moving tactile surface is positioned above, and in sliding contact with, the touchpad. This surface is translated relative to the touchpad by a high bandwidth actuator through a high fidelity mechanical linkage.

In this embodiment, a translating surface 272 is positioned over a touchpad 274, similar to the embodiment of Fig. 9. An extension member 276 can protrude in a direction (x-direction

here) towards a rotary actuator 278, which in this example is grounded to the laptop housing 280. The actuator 278 can be a DC rotary motor having a rotatable shaft 282 that is coupled to a coupling linkage 284 that is in turn coupled to the extension member 276. For example, a portion of the linkage from the actuator assembly 150 described above can be used. When the actuator 278 rotates the shaft 282 in either direction, the linkage converts the rotation to surface 272 translation in a corresponding direction (left or right). For example, a displacement of about +/- 1 mm can be achieved. The user feels the surface translation when moving a finger over the surface 272. Motor rotation can result in very clean high fidelity translation in the X axis. A DC motor design may work in a laptop given spare volume out at the sides or locations in the front of the enclosure or housing. A similar extension, linkage and motor can be provided in the y-direction to move the surface 272 in that direction. The input of the user is detected on the touchpad through the moving tactile surface.

The thin surface can be trimmed to fit inside the touchpad area with a small border all around. A rectangular extension can be cut out of a larger lamination to provide a fairly rigid strip that is driven with an actuator. This strip should be wide enough to allow the actuator to push on it in operation without the strip buckling.

As in the embodiment of Fig. 9, a smooth surface can be provided on the underside of surface 272 that contacts the touchpad to provide a smooth low-friction sliding interface with the touchpad plastic covering that the user's finger normally touches. The top side of the moving surface 272 can be made frictional to allow a good user grip, e.g. a texture like fine sandpaper. This can provide an excellent contact surface because it provides some mechanical bonding with the finger surface, but is not rough enough to feel rough to touch. Other embodiments can use a variety of types of friction surfaces. Other embodiments may also use flatter actuators, such as moving magnet actuators or voice coil actuators.

Two strips 286 of plastic or other material can be attached to the bezel surrounding the touchpad (i.e. the rim of the housing opening for the touchpad) and covering the edges of the surface 272 in order to constrain the moving surface 272 and keep it flat against and parallel to the touchpad 274.

The embodiments of Figs. 9 and 10 can provide compelling haptic sensations. Adding a surface above the touchpad does not substantially interfere with the sensor operation of the touchpad. A user can concurrently point and receive haptic feedback through motion of this surface relative to the fixed touchpad. It is simple for the user to provide input to the laptop or other electronic device when touching and moving a finger over the translation surface above the touchpad. In some embodiments, the moving surface can be held above, not in close contact with, the touchpad and so some compression by the user may be required to take the free play out and come into proximity with the sensor array.

When moving a cursor over displayed scroll bars and around on the desktop GUI displayed by the laptop, the user feels distinct, high fidelity effects that are well correlated spatially with the cursor. The character of the correlation may be different depending on whether the user moves a finger or object in the x- or the y-axis. The actuator in the shown embodiment 270 moves the surface 272 in the x-axis. Consequently, moving the cursor up and down over icons, the user may feel pops or similar tactile effects as unidirectional if the user does not concentrate on or observe that the motion of the surface 272 is perpendicular to the cursor motion.

Motion of the user's finger in the translated direction -- the x-axis in the example of Fig. 10 -- tends to be more compelling. For example, as the user drags a finger in the x-direction to move a cursor from one displayed radio button to the next, the surface 272 may lead the user into the next button and can feel like a detent even though very small motions of the surface are being generated. A surface translation force opposing the direction of motion can be effective, e.g. if the user is moving left onto an icon, a translation force directed to the right feels crisp and natural. If haptic feedback is allowed in only one axis, the y-axis may be a better choice in some embodiments because there may be more vertically-oriented content on a GUI desktop and in applications.

A short, distinct pulse can provide excellent transitions when moving the cursor from one object to another, such as between graphical buttons. Vibrations can be conveyed to the user in surface translation embodiments by oscillating the actuator driving the surface, e.g. with a sine or other periodic wave, and thereby oscillating the translating surface in opposite directions.

The user also may naturally tend to take his or her finger off of the touchpad between motions that control the cursor, and an inherent spring centering of the motor and linkage can return the moving surface 252 or 272 to a neutral (origin) position, ready for the next interaction. The controlled cursor is not moved while the feedback apparatus has moved back to the neutral origin position, since only the surface above the touchpad moves and does not provide input to the computer through the touchpad like a user's finger.

Motion in a particular direction allows the surface translation embodiments to act in some embodiments as a relative pointing device with local pseudo-kinesthetic feedback. Tactile feedback is still the primary type of haptic feedback provided in such an embodiment, but the small displacements of the surface can be dramatically perceived as directed spring forces acting in such a way that they feel like detent "slopes" that force the user's finger in a direction, even though they are just pops.

The overall stiffness of the actuator can affect results. If the user presses too strongly on the moving surface, then the user may move the surface while dragging / pointing the finger and this can run the actuator out of its spring center. A preferred embodiment has a forceful but stiff actuator, one that the user can barely back-drive by pressing strongly.

Having particular amount of travel or compliance on the moving surface, e.g. about 2 mm, is desirable in some embodiments. There is a strong spring centering from the motor and linkage, and moving the cursor between two objects, such as buttons in a GUI, can be very realistic because the user may perceive true kinesthetic force feedback until finger pressure is decreased and the finger is moved quickly across the screen in a relative mode. The haptic effects which are output are simple tactile pops, and no actual kinesthetic springs are providing force in the X or Y directions. However, the user senses that his or her finger is being pulled into an adjacent object, e.g. the next button.

It should be noted that kinesthetic force feedback is possible in a different embodiment. For example, if the user keeps his or her finger in one place on the moving surface, and the moving surface has a large enough displacement, forces can be output in the degrees of freedom of motion of the moving surface, providing kinesthetic force feedback. The sensor of the touchpad can be used as the sensor indicating the position of the finger/moving surface for computation of the force, such as a spring force having a magnitude dependent on the distance that is moved from an origin of the spring. Thus, such an embodiment would be a dual mode haptic system, including both tactile and kinesthetic modes.

Some embodiments of the moving surface may allow sliding by the user, while others may be very stiff with little sliding. In many embodiments, if the maximum permitted movement of the surface is enough to allow traversal between two adjacent graphical targets, then the kinesthetic mode can be effective and user may not notice that he or she is moving the surface. Some embodiments can provide translation and forces in two axes (X and Y), allowing this kinesthetic directed feedback (real springs) in all directions of the touchpad.

Haptic effects may not feel the same if the user is not moving his or her finger or object on the touchpad. There is often content and value in the correspondence of touchpad motion with the haptic effect (e.g., a detent pop effect). For example, it is effective when the user finger is moving and receiving the pop effect when the finger translates the moving surface to the transition point between the icons or buttons.

Many of the advantages described above for separate translating surfaces are also applicable to translating the touchpad surface, described in detail below.

FIGURE 11 is a perspective view of another embodiment 290 of a separate translating surface and moving coil actuator. In this embodiment, a frame 292 is positioned over the touchpad 294 of the device. Frame 292 includes a thin surface portion 296 which is located directly above the touchpad 294 and is thin enough to allow the user's contact on the portion 296 to be detected by the touchpad 294 underneath. Frame 292 also includes an integrated voice coil 298 which is part of a voice coil actuator 300. The coil 298 can be wire traces that are molded into the frame 292, which can be a PCB. The other parts of the actuator 300 include a stationary two-pole magnet 302 positioned over the coil 298 and grounded to the laptop housing, and a backing plate 304 made of steel, positioned on the other side of frame 292 and grounded to the housing, and used for a flux return path. The steel subassembly can be attached to the touchpad PCB itself, for example.

Thus, the magnetic fields of the magnet 302 and the current flowing through coil 298 interact to cause a linear force on the frame 298, which causes the frame and portion 296 to move as indicated by arrow 306. This provides haptic sensations to the user similarly to the separate translating surface embodiments described above. The housing can surround the entire frame except for an opening surrounding the portion 296 of the frame 292. In some embodiments, wires from the coil 298 can be connected to the touchpad PCB using a separate flex circuit finger that branches off of the moving frame 292.

FIGURE 12 is a perspective view of another embodiment 310 of a separate translating surface. In this embodiment, a surface surrounding the touchpad is translated in x- and/or y-direction with respect to the touchpad surface. Thumb surface 312 is positioned at the bottom side of the touchpad 314 and is rigidly coupled to a link member 295. Link member 316 is coupled to a flexible link 318, which is coupled to the rotatable shaft of an actuator 320 that is grounded to the laptop housing. When the actuator 320 rotates the shaft, the flexible link 318 moves the link member 316 linearly as indicated by arrow 322, which moves the thumb surface 312 linearly along the x-axis. The thumb surface 312 is shown in sliding contact with a standard button (not shown) which is directly underneath the surface 312.

The user can rest his or her thumb, palm, or finger on the thumb surface 312 while operating the touchpad in order to feel the haptic sensations. To press the button located underneath the thumb surface 312, the user simply presses down on the surface 312. Overall, the sensations tend to be similar to the sensations for the other translating surfaces described above. In other embodiments, the link member 316 can be much longer to allow desired placement of the actuator 320 in the housing of the laptop or other device.

One disadvantage is that there is no feedback to the user unless the user has a thumb, finger, or palm on the thumb surface area. The user may have to reach for other buttons to type and then lose the haptic experience. A larger surface 312 or palm pad extension can be used in

embodiments in which it may be difficult to keep the user's thumb on the surface 312 while using the same hand to point with the touchpad.

Touch Device Translation

These embodiments translate the touchpad (or touchscreen) surface itself rather than moving a separate surface. The user feels the translating touchpad moving laterally, in shear with his or her skin, creating an immediate sensation. The touchpad can be moved relative to a fixed surround, such as a laptop housing.

FIGURE 13 is a perspective view of one embodiment 330 providing a translating touchpad surface. Touchpad 332 is moved relative to a housing 334, such as a laptop or PDA housing, by an actuator 336. In the described embodiment, the actuator 336 is a rotary actuator, such as a DC motor, having a rotating shaft 338 that is coupled to a linkage 340. The linkage 340 is coupled to a bracket 342 at its other end, where the bracket 342 is coupled to the underside of the touchpad 332 module. The linkage includes joints and/or flexibility/compliance to allow the rotational motion of the shaft 338 to be converted to linear force on the bracket 342, thereby causing the touchpad 332 to move laterally as shown by arrows 344. For example, the linkage can be made of polypropylene, similar to the linkages of the actuator assembly of Fig. 5. The laptop housing can serve as a constraining structure for the moving touchpad module.

For example, a standard DC motor can be used for actuator 336 and a polypropylene linkage assembly for linkage 340. In one embodiment, the haptic feedback components can reside where optional components for the laptop are normally placed, such as an optional disc drive.

In other embodiments, the actuator 338 can be located remotely from the touchpad 332, e.g., wherever space is available in the housing as opposed to directly underneath the touchpad as illustrated in Fig. 13. Linkages can be used to locate the actuator(s) remotely from the touchpad, as shown in Fig. 14 below.

Translating the entire touchpad in one or two axes may be one good overall haptics approach. Very small displacements ($0.2mm \leq x \leq 0.5mm$) of the touchpad are desired to provide useful haptics. The power consumption for this embodiment when evaluated within a practical magnitude range can be less than the consumption of currently available internal mice interface devices, which can receive all needed power over the interface to the host computer, such as USB.

Some advantages are apparent in this type of embodiment. Feedback experience is direct, well correlated with pointing, and precise. Implementation can be flexible and

unobtrusive, and addition of haptic components does not alter how the touchpad is used. The translating surface has a small displacement requirement compared with inertial approaches – this can lead to reduced power consumption and manufacturing benefits. In some embodiments, the motion of the touchpad can be oriented at an angle in the x-y plane. Some disadvantages may include use of a DC motor, which are relatively large, a flexible linkage may need a lot of clearance and may cause friction, and power consumption may be relatively high.

FIGURE 14 illustrates a perspective view of another embodiment 350 of a moving touchpad, in which the touchpad may be moved in both X and Y directions. The touchpad 351 is directly coupled to a first linkage member 351, which is coupled to a rotating shaft of an actuator 353 by a flexible member 354, such as polypropelene. Actuator 353 is grounded to the laptop housing. When actuator 353 rotates its shaft, the flexible member 354 converts the rotary motion to linear motion and translates the linkage member 352 in the x-direction, which in turn translates the touchpad as indicated by arrow 355. At the distal end of the first linkage member 354, a second linkage member 356 is coupled, e.g. by a flexible coupling.

A second actuator 358, grounded to the laptop housing, is coupled to the other end of the second linkage member 356 by a flexible member 357, where the axis of rotation of the rotating shaft of the actuator 358 is substantially the same as the axis of rotation of the actuator 353. The rotary force output by the rotating shaft of the actuator 358 is converted to a linear force by the flexible member 357. This linear force causes the second linkage member 356 to move linearly along its length, which in turn causes the first linkage member 352 to pivot approximately about its end near actuator 353 along the y-axis and cause the touchpad 351 to move approximately along the y-axis. The actuators 353 and 358 can be, for example, DC motors or any other type of actuator, e.g. linear actuators can also be used, as described below in Figs. 15-17. The linkage members can be made of any suitable material, e.g. carbon fiber. Preferably, very little energy is absorbed by the grounded structure or by unwanted deformations in the linkage assembly.

Thus, the mechanism decouples the x- and y-motions; by activating actuator 353, x-axis motion is provided, and by activating actuator 358, y-axis motion is provided; both x- and y-axis motion can be provided by activating both motors simultaneously. Both actuators can be driven either together (common mode) or differentially (differential mode) to achieve pure X or Y movement without binding the linkage parts. Furthermore, any combination of drive current will produce a resultant force along any arbitrary axis with the same fidelity and lack of binding.

One embodiment may use firmware for rapid evaluation and output of X and Y forces, e.g. software running on a local controller such as a microprocessor, or running off the host CPU. In some embodiments, such firmware may be too complex, so that alternatively, a

mechanism with an electronic way of switching between the two principle feedback axes can be used. In one embodiment, the two DC motors can be connected in a series circuit with switch that reverses the current through one of the two motors.

In the embodiment of Fig. 14, the user may feel the difference between x- and y-directional forces when moving a finger or object on the touchpad in the x-direction. There is haptic value in having the correlation or alignment of tactile feedback with finger/cursor motion; in some cases, alignment can boost the haptic signal-to-noise ratio. For example, moving the cursor right to left over icons or buttons may feel better and more like real buttons to the user when the feedback is directed horizontally along the x-axis. Less power may be required overall if the feedback is aligned with the cursor direction instead of being omnidirectional or misaligned. In some cases, a weaker aligned haptic effect may be more meaningful than a stronger misaligned effect.

The touchpad surface with enhanced texture moves relative to a fixed surrounding surface with enhanced texture. The enhanced texture is more rough, corrugated, or otherwise textured, allowing a stronger user contact.

In some other embodiments, the touchpad surface can be comprised of interdigitated surface features that move relative to each other in x- and/or y- directions. For example, two halves of a touchpad can be driven by actuator(s) to move relative to each other.

In other embodiments, other actuators can be used to move the touchpad, touchscreen, or other touch device in the z-direction. For example, piezo-electric actuators, voice coil actuators, or moving magnet actuators can be directly coupled to the touchpad or touchscreen to provide direct motion of the touch surface. Also, the touchpad surface can be comprised of a fixed tactile surface and a reference surface, where the reference surface can displaced along the z-axis with respect to the fixed tactile surface.

FIGURES 15a and 15b are perspective views of the top side and bottom side, respectively, of a different embodiment of a novel "flat-E" actuator 360 for use in translating a touchpad. FIGURE 15c is a side view of the actuator 360. Actuator 360 is designed to be very flat and thus may be more appropriate to function within a flat assembly that can be inherently part of the touchpad, touchscreen, or other similar input device. "E-core" actuator topology provides an excellent actuator using minimal magnet material and delivers good force and bandwidth. One disadvantage of the moving magnet actuator is the large depth required ("E" core ferromagnetic piece width can be traded for height to some extent, perhaps reducing the overall depth of the actuator).

Actuator 360 presents a inventive embodiment of an "E" core that can be used to translate the touchpad (or alternatively to translate a separate surface, as in the embodiments of Figs. 9-14). A folded over, flat 3-D embodiment, shown in Figs. 15a-15b, that may behave substantially like a 2-D case, but with more leakage and non uniform flux at the poles.

Actuator 360 includes a ferromagnetic piece 362 shaped as an "E", which can be made of a metal such as a ferrous metal or carbon steel plate, and can be a single piece of metal or a lamination. A coil 364 of wire is wound about the central pole of the "E" of the ferromagnetic piece 362. A floating plastic cage 368 can be positioned on the ferromagnetic piece 362 and can include two or more rollers 370 positioned in apertures in the cage and oriented so that the rollers roll about axes parallel to the axis passing through the coil 364 about which the coil is wound. The cage can be plastic and is floating, i.e. unattached to other components, to allow the rollers to roll. A two-pole magnet 366 is positioned above the poles of the ferromagnetic piece 362 and cage 368 so that there is an air gap between magnet and ferromagnetic piece. The magnet 366 is coupled to the underside (in the orientation of the figures; other orientations are possible) of a backing steel piece 372 which is positioned on top of and contacting the rollers 370. The rollers thus set the nominal magnetic gap between the magnet and the ferromagnetic piece 362. The backing steel piece 372 can be rigidly coupled to the touchpad 373, as shown in FIGURE 15d, so that the touchpad, steel piece 372, and magnet 366 can translate relative to the ferromagnetic piece 362. For example, the magnet may in some embodiments be a two pole bonded neodymium wafer, and the steel parts may be stamped from single sheets about 1 mm thick. Additional rollers or foam can be used to support the end of the ferromagnetic piece opposite the magnet 366. The magnet, cage, and backing piece are located to the side of the "E" poles rather than at the front edge as in other E-core type actuators; this allows the actuator of the present invention to be made very flat for laptop and other portable device applications.

In operation, an electrical current is flowed through the coil 364, which causes magnetic flux to flow through the ferromagnetic piece in the direction of arrows 374. In reaction, the steel plate 372 moves in a direction along the axis indicated by arrow 376 (the direction is dependent on the direction of the current in the coil). The rollers 370 rotate to allow the steel plate 372 and magnet 366 to translate relative to the ferromagnetic piece 362. The floating cage 368 keeps the rollers from moving in undesired directions as they rotate. Also, the magnetic attractive normal forces which occur between ferromagnetic piece 362 and magnet 366 are reacted with the rollers 370. Other Flat-E related embodiments can include flexure and knife-edge suspensions to react (allow motion from) magnetic normal forces.

The flat E actuator embodiments described herein can be used to translate the touchpad (or touchscreen) or a separate surface member above or to the side of the touchpad. For

example, two flat E actuators can be used in a configuration similar to that of Fig. 9 to drive the touchpad or surface member in two axes, x and y.

The actuator 360 can be made very thin in comparison with other actuators, e.g. the assembly can be made approximately 3 or 4mm thick, less than half as thick as other "E" core actuators. The magnetics design can be iterated for optimal performance. Linearity and detent forces can be traded for thickness.

Advantages include a planar, thin geometry, which is suitable for laptops, PDA, and other portable devices. The moving magnet approach does not require a large air gap so it may be more attractive for laptop haptic feedback. An "E" core prototype was 10mm X 20mm X 8mm and is smaller than most DC motors with equivalent force and power consumption. Furthermore, it is a direct drive configuration, so no transmission is required between actuator and touchpad. Efficient, low cost, and easy to manufacture components allow the actuator to be produced cheaply. The actuator is simple to integrate with existing touchpad PCB's and modules. One disadvantage is that magnetic attractive normal forces exist, which may necessitate a suspension. Rollers and/or flexure and knife edge suspensions can be used in some embodiments to react magnetic normal forces.

The actuator 360 generally provides good bandwidth. Larger (e.g., > 1mm) displacements can be achieved. Those embodiments employing foam to support the opposite end of the ferromagnetic piece have a return spring having a low spring constant, mostly from the foam suspension operated in shear mode. Audible noise may also be reduced by using the foam and/or rollers. While the haptic performance is good, the displacement of the surface is small enough so that when the user is moving a finger over the touchpad to move the cursor over the desktop, the surface displacement does not noticeably affect the cursor motion.

FIGURES 16a and 16b are perspective views of the top side and bottom sides of another embodiment 380 of the "flat-E" actuator of Figs. 15a-15c. A ferromagnetic piece 382 (or a lamination, in other embodiments) includes an approximate "E" structure and has a coil 384 wound around the E center pole 385. A two-pole magnet 386 is positioned across the E center pole 385 such that a gap is provided between ferromagnetic piece 382 and magnet, similarly to the embodiment 360. A metal plate 388 (e.g., steel) is coupled to magnet 386 and is provided parallel to the ferromagnetic piece and magnet. A cage 390 can be provided as the middle layer, where rollers 389 (shown as dashed lines) can be positioned within apertures in the cage 390 and allow the plate 388 to slide laterally with respect to the ferromagnetic piece and magnet. A touchpad or touchscreen (not shown) can be rigidly coupled to the top of plate 388, with piece 382 grounded. In alternate embodiments, the touchpad or touch screen can be coupled to the piece 382 with plate 388 grounded.

Embodiment 380 also includes a flexible suspension, which can be coupled to the middle layer plastic cage 390 and can include two linkages 392 that are thus effectively coupled between the steel plate 388 and the ferromagnetic piece 382. The linkages 392 contact the steel plate 388 at ends 394 and are coupled to the cage layer 390 at ends 396 (or molded with the cage layer as a single plastic piece). Each linkage includes a thinner portion 398 and a thicker portion 400.

In operation, a current is flowed through coil 384 and the magnetic forces resulting from the current and magnet 386 cause the plate 388 (and the touchpad) to move as indicated by axis 402. The suspension including linkages 392 prevents the plate 388 from skewing due to magnetic normal forces and any other forces. Each linkage 392 flexes to accommodate the motion of the plate 388, where the thinner members 398 flex first, and the thicker members 400 flex if the limits of flex are reached for members 398. The thinner-thicker structure allows spring centering to operate until the thicker (stiffer) beams are engaged, which provide a softer feeling stop to motion. The final limit to motion is caused by either of the stops 404 hitting the inner edge of the plate 388.

The flexible suspension described above effectively allows lateral desired motion of the plate and touchpad, but prevent motion in any other direction. This creates a much more stable motion of the plate 388 and does not allow the plate 388 to drift in its position over time. Furthermore, the suspension provides a desirable spring centering force on the plate 388 and touchpad, allowing the touchpad to move to the center of its range of motion when the user stops touching and forcing the touchpad.

FIGURES 17a-17g are views illustrating another flat-E actuator touchpad embodiment 420 that miniaturizes this type of actuator and provides fabricated surface mount devices that take advantage of existing lead frame and over molding manufacturing technologies. Such small scale devices can be wave soldered onto the touchpad module and can work in parallel to provide suitable stroke and force for touchpad translation (or for z-axis forces in alternate embodiments).

Figures 17a-17c illustrate a top view of a PCB 422 which includes multiple Flat-E actuators 424. An actuator 424 can be positioned at each corner of the PCB 422 as shown. More or less actuators than shown can alternatively be placed in other configurations. The use of multiple actuators 422 can provide greater magnitude forces and allow each actuator 422 to have a lower force output and cost. In one embodiment, the PCB 422 is a separate PCB that is grounded to the housing of the laptop. The touchpad (e.g., including its own PCB different from PCB 422) is then coupled to the moving portions of the actuators, e.g., to the pads 426 shown in Fig. 17a. In another embodiment, the PCB 422 is the touchpad, and the moving portions of the actuators are coupled to a grounded surface in the laptop, such as the housing.

In such an embodiment, the actuators 424 can be hidden from the user by a lip of housing that extends around the perimeter of the touchpad, leaving the center area of the PCB 422 exposed to the user.

Fig. 17d is a side elevational view of one end of a PCB 422, separate from the touchpad, that includes the flat-E actuators 424. The touchpad/PCB member 428 is coupled to the moving portions 430 of the actuators 424.

Fig. 17e is a perspective view illustrating one embodiment of the underside of the PCB 422 shown in Fig. 17a, where the flat-E actuators 424 have been surface mounted to the underside of the PCB 422. This can be done as "hand-placed" components, or preferably using automatic surface mount technology placement equipment. The "E" ferromagnetic piece 432 can be grounded to the PCB 422 so that the magnet and steel backing plate of the actuator move.

Figs. 17f and 17g are perspective views illustrating top and bottom views, respectively, of the flat-E actuator 424 which has 3 poles and can operate similarly to the flat-E actuators described above. Ferromagnetic piece 432 is shaped like an "E" and has a coil 434 wrapped about the center pole. Flexures 436 allow the magnet 438 and steel backing plate 440 to move relative to the ferromagnetic piece 432 and coil 434. The touchpad (not shown) can be coupled to the steel backing piece 440 and the E-laminate piece 432/coil 434 can be grounded, as in the embodiments of Figs. 17a-17e. Alternatively, the backing piece 440 and magnet 438 can be grounded and the touchpad can be coupled to a moving ferromagnetic piece 432.

A flat-E actuator as described above can be used to translate touchpad modules or palm surfaces directly. In the described embodiments, the total thickness of the flat-E actuator can be about 3 mm or less. Flat-E magnetic assemblies that can be integrated into the an existing touchpad product line represent a preferred embodiment in terms of size, manufacturability and economy of scale.

In other embodiments, other moving magnet actuator designs, and other voice coil actuator designs, such as described in U.S. Patent Nos. 6,166,723 and 6,100,874, can be used.

In other embodiments, other types of input surfaces or display screens can be similarly translated using any of the actuators described herein. For example, a clear surface such as the input sensing device(s) covering a display screen of a personal digital assistant (PDA) or a touch screen on a monitor or CRT, can be similarly translated in the X and/or Y directions (parallel to the screen surface) to provide haptic feedback. One application for such clear screen translation is ATM machines, where the user typically inputs information on a touch screen. Haptic feedback can make such input more accessible and easy for people with below-

average vision. Haptic feedback can indicate when the user's finger is over a graphically-displayed button, or can identify particular displayed buttons with different haptic sensations. 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.

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

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. 16a-16b. 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.

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.

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).

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.

FIGURE 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 a 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.

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.

Another type of force sensation that can be output on the touchpad is a texture force. This type of force is similar to a pulse force, but depends on the position of the user's finger on the area of the touchpad and/or on the location of the cursor in a graphical environment. Thus, texture bumps can be output depending on whether the cursor has moved over a location of a bump in a graphical environment. This type of force is spatially-dependent, i.e. a force is output depending on the location of the cursor as it moves over a designated textured area; when the cursor is positioned between "bumps" of the texture, no force is output, and when the cursor moves over a bump, a force is output. This can be achieved by the host sending the pulse signals as the cursor is dragged over the grating, or, a separate touchpad processor can be dedicated for haptic feedback with the touchpad, and the texture effect and be achieved using local control (e.g., the host sends a high level command with texture parameters and the sensation is directly controlled by the touchpad processor). In other cases a texture can be performed by presenting a vibration to a user, the vibration being dependent upon the current velocity of the user's finger (or other object) on the touchpad. When the finger is stationary, the vibration is deactivated; as the finger is moved faster, the frequency and magnitude of the vibration is increased. This sensation can be controlled by the touchpad processor (if present), or the host. Other spatial force sensations can also be output. In addition, any of the described force sensations herein can be output simultaneously or otherwise combined as desired.

Different types of graphical objects can be associated with haptic sensations. Haptic sensations can output on the touchpad based on interaction between a cursor and a window, menu, icon, web page link, etc. For example, a "bump" or pulse can be output on the touchpad to signal the user of the location of the cursor when the cursor is moved over a border of a window. In other related interactions, when a rate control or scrolling function is performed with the touchpad (through use of the cursor), sensations can be output related to the rate control functions. Furthermore, the magnitude of output forces on the touchpad can depend on the event or interaction in the graphical environment, including user-independent events. These force sensations can also be used in games or simulations. These and other haptic sensations are described in U.S. Patent No. 6,211,861. Other control devices or grips that can include a

touchpad of the present invention in its housing include a gamepad, mouse or trackball device for manipulating a cursor or other graphical objects in a computer-generated environment, or a pressure sphere or the like.

Some forms of touchpads and touchscreens allow the amount of pressure the user is exerting on the touchpad to be sensed. This allows a variety of haptic sensations to be determined based at least in part on the sensed pressure. For example, a periodic vibration can be output having a frequency that depends on the sensed pressure. Or, the gain (magnitude) of output haptic sensations can be adjusted based on the sensed pressure. Those users that always tend to use the touchpad with more pressure can be allowed to select an automatic magnitude increase that would be in effect constantly.

Other embodiments of touchpads and touchscreens allow the user to enter "gestures" or shortcuts by tracing a symbol on the cursor control region or other region, which is recognized as a command or data by a processor. Haptic sensations can be associated with or dependent on particular gestures. For example, a confirmation of modes can be conveyed haptically with a particular haptic sensation when a mode confirmation gesture is recognized. Characters recognized from gestures also may each have a particular haptic sensation associated with them. In most touchpad embodiments, a user can select a graphical object or menu item by "tapping" the touchpad. Some touchpads may recognize a "tap-and-a-half" or double tap, which is the user doing a tap and then again touching the pad and maintaining the finger or object on the pad while moving the finger. For example, such a gesture can provide a "drag" mode in which objects may be moved with the cursor. When the user is in such a drag mode, a vibration or other haptic sensation can be output to indicate to the user that this mode is active.

As stated above, the touchpad 450 can also be provided with different control regions that provide separate input from the main cursor control region 452. In some embodiments, the different regions can be physically marked with lines, borders, or textures on the surface of the touchpad 450 (and/or sounds from the computer 10) so that the user can visually, audibly, and/or or tactilely tell which region he or she is contacting on the touchpad.

For example, scroll or rate control regions 454a and 454b can be used to provide input to perform a rate control task, such as scrolling documents, adjusting a value (such as audio volume, speaker balance, monitor display brightness, etc.), or panning/tilting the view in a game or simulation. Region 454a can be used by placing a finger (or other object) within the region, where the upper portion of the region will increase the value, scroll up, etc., and the lower portion of the region will decrease the value, scroll down, etc. In embodiments that can read the amount of pressure placed on the touchpad, the amount of pressure can directly control the rate of adjustment; e.g., a greater pressure will cause a document to scroll faster. The region

454b can similarly be used for horizontal (left/right) scrolling or rate control adjustment of a different value, view, etc.

Particular haptic effects can be associated with the control regions 454a and 454b. For example, when using the rate control region 454a or 454b, a vibration of a particular frequency can be output on the touchpad. In those embodiments having multiple actuators, an actuator placed directly under the region 454a or 454b can be activated to provide a more localized tactile sensation for the "active" (currently used) region. As a portion of a region 454 is pressed for rate control, pulses can be output on the touchpad (or region of the touchpad) to indicate when a page has scroll by, a particular value has passed, etc. A vibration can also be continually output while the user contacts the region 454a or 454b.

Other regions 456 can also be positioned on the touchpad 450. For example, each of regions 456 can be a small rectangular area, like a button, which the user can point to in order to initiate a function associated with the pointed-to region. The regions 456 can initiate such computer functions as running a program, opening or closing a window, going "forward" or "back" in a queue of web pages in a web browser, powering the computer 10 or initiating a "sleep" mode, checking mail, firing a gun in a game, cutting or pasting data from a buffer, saving a file to a storage device, selecting a font, etc. The regions 456 can duplicate functions and buttons provided in an application program or provide new, different functions.

Similarly to regions 454, the regions 456 an each be associated with haptic sensations; for example, a region 456 can provide a pulse sensation when it has been selected by the user, providing instant feedback that the function has been selected. For example, a haptic sensation such as a pulse can be output when the user "taps" a finger or object on a region 456, 452, or 454 to make a selection. Similar to physical analog buttons that provide a range of output based on how far the button is pushed, one or more regions 456 can be an analog-like button by providing a proportional, stepped, or analog output based on the pressure the user is exerting on the touchpad.

Furthermore, the same types of regions can be associated with similar-feeling haptic sensations. For example, each word-processor related region 456 can, when pointed to, cause a pulse of a particular strength, while each game-related region 456 can provide a pulse of different strength or a vibration. Furthermore, when the user moves the pointing object from one region 454 or 456 to another, a haptic sensation (such as a pulse) can be output on the touchpad 450 to signify that a region border has been crossed. For example, a high frequency vibration which quickly decays to zero magnitude can be output when the pointing object enters a designated region. This can be valuable since it provides an indication of the borders to the regions 454 and 456 which the user would not otherwise know. This also allows region reconfiguration of size and/or location and allows the user to quickly learn the new layout.

haptically. Regions can also be associated with "enclosures" which define areas in a graphical environment and the different haptic sensations which are output when the cursor enters, exits, and is moved within the enclosure and the particular borders having such haptic associations.

In addition, the regions are preferably programmable in size and shape as well as in the function with which they are associated. Thus, the functions for regions 456 can change based on an active application program in the graphical environment and/or based on user preferences input to and/or stored on the computer 10. Preferably, the size and location of each of the regions can be adjusted by the user or by an application program, and any or all of the regions can be completely removed if desired. Furthermore, the user is preferably able to assign particular haptic sensations to particular areas or types of areas based on types of functions associated with those areas, as desired. Different haptic sensations can be designed in a tool such as Immersion Studio™ available from Immersion Corp. of San Jose, CA.

It should be noted that the regions 454 and 456 need not be physical regions of the touchpad 450. That is, the entire touchpad surface need merely provide coordinates of user contact to the processor of the computer and software on the computer can designate where different regions are located. The computer can interpret the coordinates and, based on the location of the user contact, can interpret the touchpad input signal as a cursor control signal or a different type of signal, such as rate control, button function, etc. (e.g. a driver program can provide this interpreting function if desired). A touchpad microprocessor, if present, may alternatively interpret the function associated with the user contact location and report appropriate signal or data to the host processor (such as position coordinates or a button signal), thus keeping the host processor or software ignorant of the lower level processing. In other embodiments, the touchpad 450 can be physically designed to output different signals to the computer based on different regions physically marked on the touchpad surface that are contacted by the user; e.g. each region can be sensed by a different sensor or sensor array.

Any of those embodiments described herein which provide haptic feedback to the finger or object of the user that contacts the touchpad or touchscreen may be used with the regions of touchpad 450.

While this invention has been described in terms of several preferred embodiments, it is contemplated that alterations, permutations, and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. For example, many of the features described in one embodiment can be used interchangeably with other embodiments. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention.

What is claimed is:

CLAIMS

1. A haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control, the touch control comprising:

a touch input device including an approximately planar touch surface operative to provide a position signal based on a location on said touch surface which said user contacts, said position signal representing said location in two dimensions; wherein said computer receives position information derived from said position signal; and

at least one actuator coupled to said touch input device, said actuator outputting a force on said touch input device to laterally move said touch input device approximately parallel to a surface of said touch input device to provide a haptic sensation to said user contacting said touch surface, wherein said actuator outputs said force based on force information output by said computer.

2. A haptic feedback touch control as recited in claim 1 wherein said computer positions a cursor in a graphical environment displayed on a display device based at least in part on said position signal.

3. A haptic feedback touch control as recited in claim 1 wherein said touch input device is a touchpad, said touchpad being separate from a display screen of said computer.

4. A haptic feedback touch control as recited in claim 1 wherein said touch input device is integrated in a housing of said computer.

5. A haptic feedback touch control as recited in claim 1 wherein said user contacts said touch surface with a finger of said user.

6. A haptic feedback touch control as recited in claim 1 wherein said user contacts said touch surface with a physical object held by said user.

7. A haptic feedback touch control as recited in claim 1 wherein said at least one actuator is a first actuator that outputs a first force in a first lateral direction approximately parallel to said surface of said touch input device, and further comprising a second actuator coupled to said touch input device and operative to output a second force on said touch input device in a second lateral direction approximately parallel to said surface and approximately perpendicular to said first lateral direction.

8. A haptic feedback touch control as recited in claim 1 wherein said actuator is a linear actuator that provides an output force in a linear degree of freedom, and wherein said actuator is coupled between said touchpad and a grounded housing.

9. A haptic feedback touch control as recited in claim 8 wherein said actuator is a rotary actuator that provides an output force in a rotary degree of freedom, said output force being converted to said linear force.

10. A haptic feedback touch control as recited in claim 8 wherein said actuator is an E-core actuator.

11. A haptic feedback touch control as recited in claim 10 wherein said actuator includes at least one roller allowing a backing plate of said actuator to slide relative to a magnet of said actuator.

12. A haptic feedback touch control as recited in claim 11 wherein said actuator includes a flexure providing a spring return force between said backing plate and said magnet.

13. A haptic feedback touch control as recited in claim 1 wherein said actuator oscillates said touch input device laterally.

14. A haptic feedback touch control as recited in claim 1 wherein said touch input device includes a plurality of different regions, wherein at least one of said regions provides said position signal and at least one other region provides a signal that is used by said computer to control a different function.

15. A haptic feedback touch control as recited in claim 14 wherein at least one of said regions is associated with a different haptic sensation output on said touch input device than another one of said regions.

16. A haptic feedback touch control as recited in claim 14 wherein a haptic sensation is output when said user moves a contacting object from one of said regions to another one of said regions.

17. A haptic feedback touch control as recited in claim 1 wherein said actuator is a first actuator, and further comprising at least one additional actuator coupled to said touch input device, wherein said actuators are E-core actuators that have been surface mounted to a printed circuit board.

18. A haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control, the touch control comprising:

a touch input device including an approximately planar touch surface operative to provide a position signal based on a location on said touch surface which said user presses, said position signal representing said location in two dimensions, wherein said computer receives position information derived from said position signal;

a surface member located adjacent to said touch input device, wherein said user can contact said surface when pressing said touch input device; and

at least one actuator coupled to said surface member, said actuator outputting a force on said surface member to provide a haptic sensation to said user contacting said surface member, wherein said actuator outputs said force based on force information output by said computer.

19. A haptic feedback touch control as recited in claim 18 wherein said surface member is translated laterally, approximately in a plane parallel to said planar touch surface.

20. A haptic feedback touch control as recited in claim 19 wherein said surface member is positioned over said touch input device and at least approximately coextensive with said surface of said touch input device, such that said user presses said surface member to press said touch input device.

21. A haptic feedback touch control as recited in claim 20 wherein said actuator is a linear actuator.

22. A haptic feedback touch control as recited in claim 20 wherein said actuator is a rotary actuator, wherein a linkage converts a rotary output force to an approximately linear output force on said translated surface member.

23. A haptic feedback touch control as recited in claim 18 wherein said actuator is a voice coil actuator, wherein a wire coil is physically coupled to said surface member.

24. A haptic feedback touch control as recited in claim 18 wherein said surface member is positioned to a side of said touch input device such that said user touches said touch input device with one finger and touches said surface member with a different finger or palm.

25. A haptic feedback touch control as recited in claim 21 wherein said surface member is positioned over a physical button that is located adjacent to said touch input device.

26. A haptic feedback touch control as recited in claim 18 wherein said force on said surface member is a linear force output approximately perpendicularly to a surface of said surface member.

27. A haptic feedback touch control as recited in claim 26 wherein said linear force is an inertial force output by an actuator assembly that includes said actuator and moves an inertial

mass, wherein said inertial force is transmitted through said surface member to said user contacting said surface member.

28. A haptic feedback touch control as recited in claim 18 wherein said surface member is a palm surface coupled to a housing of said computer and located to the side of said touch input device.

29. A haptic feedback touch control as recited in claim 18 wherein sound electronics of said computer are used to drive said at least one actuator.

30. An actuator providing a linear force output, the actuator comprising:

a grounded ferromagnetic piece including a center pole located between two side poles;

a coil wrapped around said center pole;

a magnet positioned adjacent to said center pole and said side poles, wherein an air gap is provided between said magnet and said ferromagnetic piece; and

a backing plate coupled to said magnet, wherein said backing plate and said magnet move with respect to said grounded ferromagnetic piece when current is flowed in said coil.

31. An actuator as recited in claim 30 further comprising rollers positioned between said ferromagnetic piece and said backing plate to allow said relative motion between said backing plate and said ferromagnetic piece.

32. An actuator as recited in claim 31 wherein said rollers are constrained by a cage member.

33. An actuator as recited in claim 30 further comprising a flexure coupled between said backing plate and said ferromagnetic piece, said flexure reducing relative motion between said backing plate and said ferromagnetic piece in undesired directions and providing a spring centering force between said backing plate and said ferromagnetic piece.

34. An actuator as recited in claim 30 wherein an entire thickness of said actuator is approximately 4 millimeters or less.

35. A haptic touch device comprising:

a piezoelectric transducer coupled to a ground, said piezoelectric transducer including a metal diaphragm coupled to a ceramic element;

a planar sensing element operative to sense a location of a contact from a user on a surface of said planar sensing element and provide information representing said location to a computer controller;

a spacer provided between said piezoelectric transducer and said planar sensing element, wherein said metal diaphragm contacts said spacer; and

EX1002 - Page 1146

a spring element coupled between said planar sensing element and said ground, said spring element providing a spring restoring force to said planar sensing element.

36. A haptic touch device as recited in claim 35 wherein said piezoelectric transducer is driven with a signal approximately at a natural frequency of said haptic touch device.

37. A haptic touch device as recited in claim 35 wherein said natural frequency can be adjusted by adjusting a spring constant of said spring element or adjusting a mass of said spacer or said planar sensing element.

38. A method for providing haptic feedback to a touch input device that provides input to a computer device, said computer device implementing a graphical environment, the method comprising:

receiving a position signal from said touch input device, said position signal indicating a contact location on a surface of said touch input device where said user is pressing said surface;

determining in which of a plurality of regions said contact location is positioned, wherein said surface of said touch input device is divided into said plurality of regions; and

providing force information to cause at least one actuator to output a force to said user operating said touch input device, said force associated with said user moving an object on or over said surface of said touch input device.

39. A method as recited in claim 38 further comprising implementing a function associated with said region in which said contact location is positioned.

40. A method as recited in claim 39 wherein said function associated with said region includes a rate control function of a value.

41. A method as recited in claim 39 wherein said function associated with said region includes moving a displayed cursor to a screen position based on said position signal.

42. A method as recited in claim 39 wherein said function associated with said region includes a function that can also be initiated by selecting a graphical button displayed by an application program running on said computer device.

43. A method as recited in claim 38 wherein said force is output when said user moves said object over a boundary to said region in which said contact location is positioned from a different region of said touch input device.

44. A method as recited in claim 38 wherein said object moved on or over said surface of said touch input device includes a finger of said user or an object held by said user.

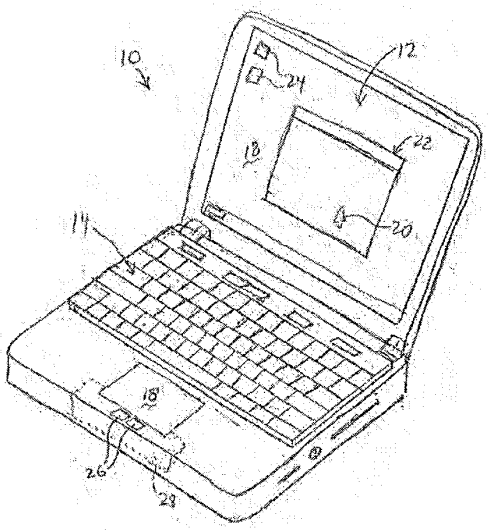


FIG. 1

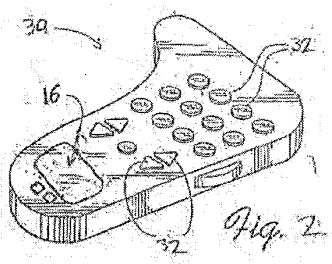


Fig. 2

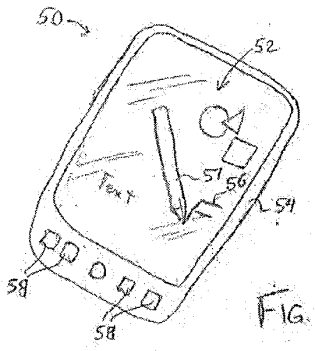


FIG. 3

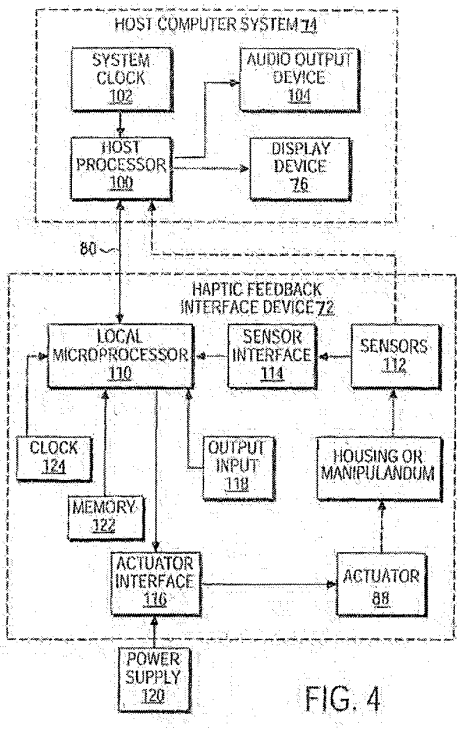

HOST COMPUTER SYSTEM 74
SYSTEM CLOCK 102
AUDIO OUTPUT DEVICE 104
HOST PROCESSOR 100
DISPLAY DEVICE 76
80
HAPTIC FEEDBACK INTERFACE DEVICE 72
LOCAL MICROPROCESSOR 110
SENSOR INTERFACE 114
SENSORS 112
CLOCK 124
OUTPUT INPUT 118
HOUSING OR MANIPULANDUM
MEMORY 122
ACTUATOR INTERFACE 116
ACTUATOR 88
POWER SUPPLY 120

FIG. 4

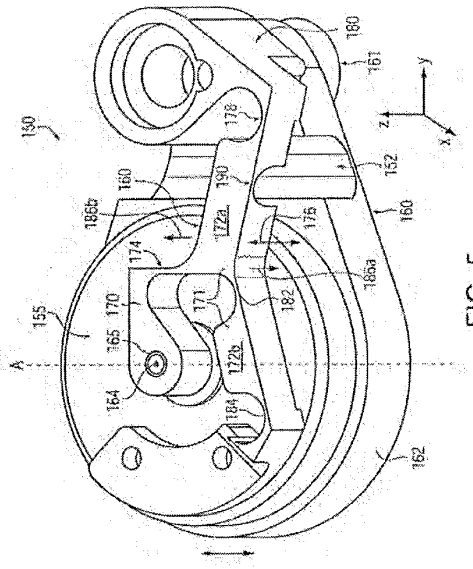

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FIG. 5

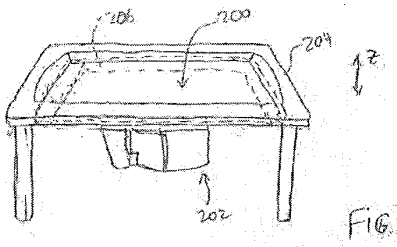


FIG. 6

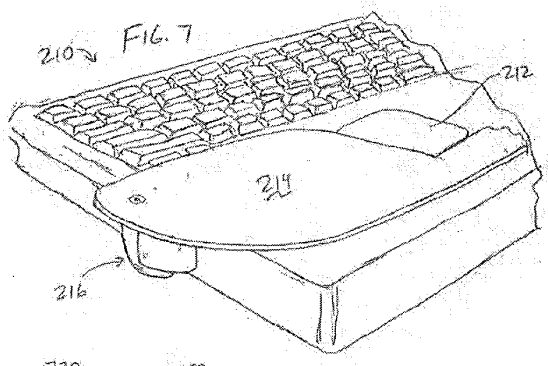


FIG. 7

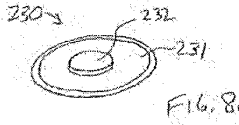


FIG. 8a

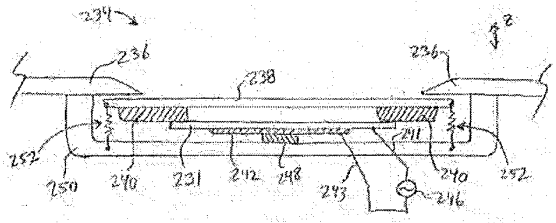


FIG. 8b

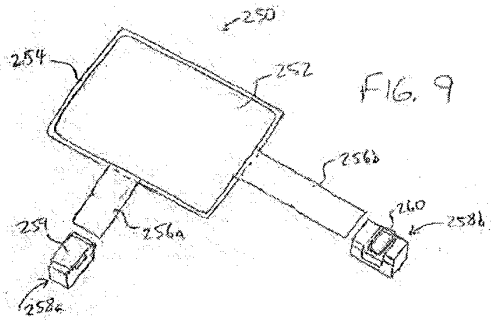

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FIG. 9

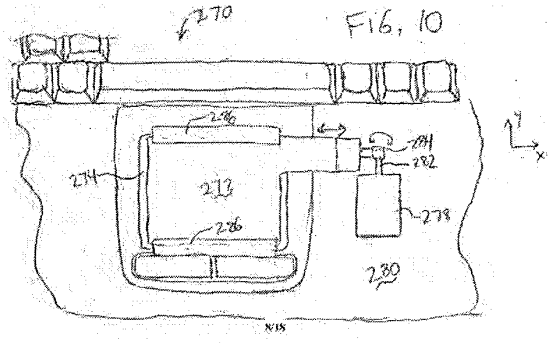
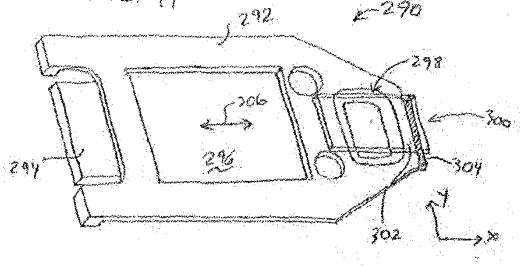

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FIG. 10

FIG. 11



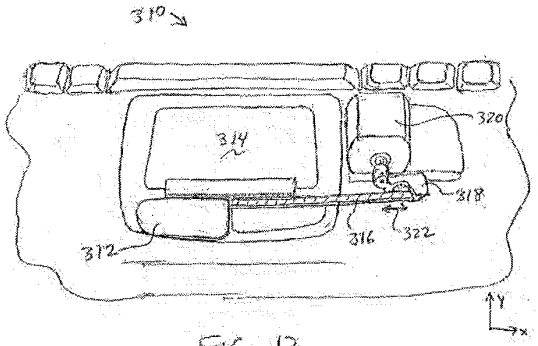


FIG. 12

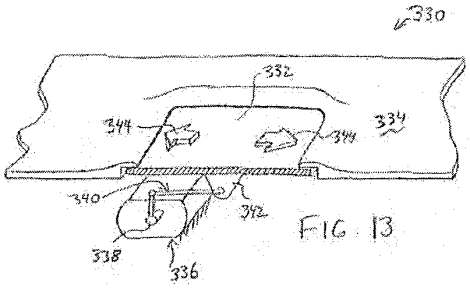

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FIG. 13

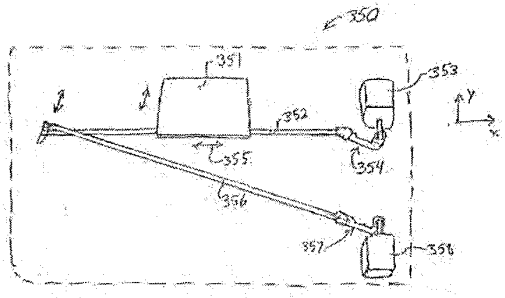

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FIG. 14

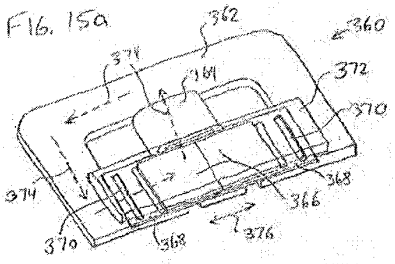


Fig. 15a

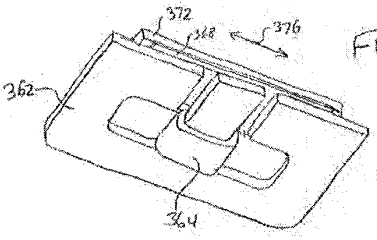


Fig. 15b

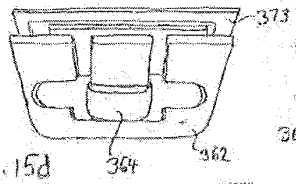


Fig. 15d

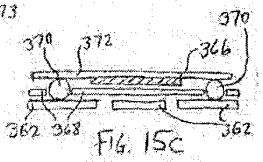


Fig. 15c

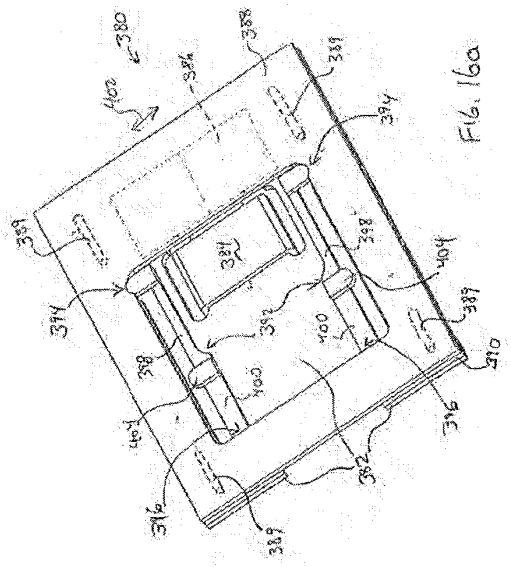


Fig. 16a

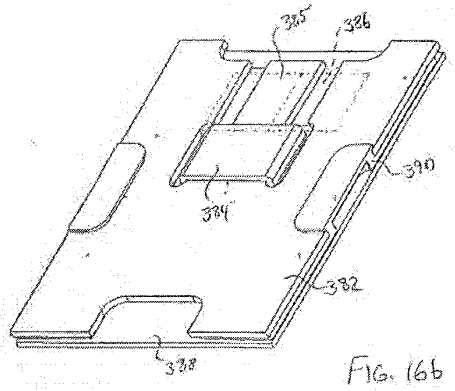


FIG. 16b

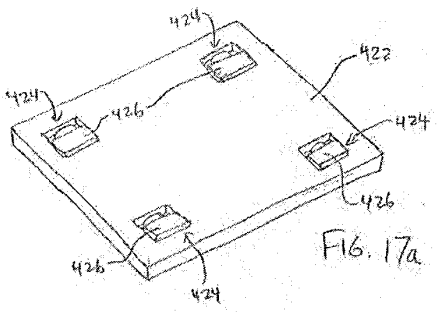


FIG. 17a

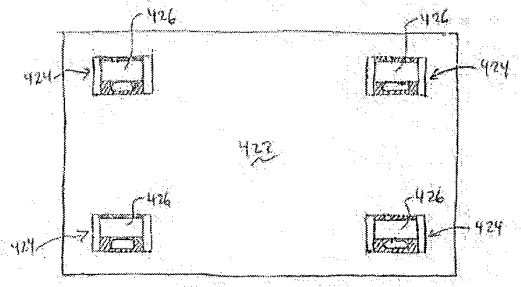


FIG. 17b

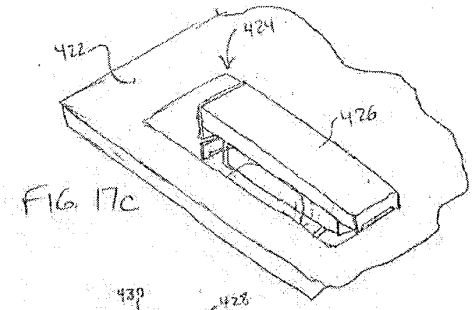


FIG. 17c

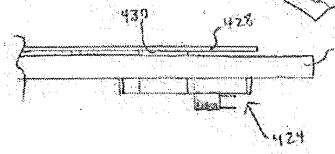


FIG. 17d

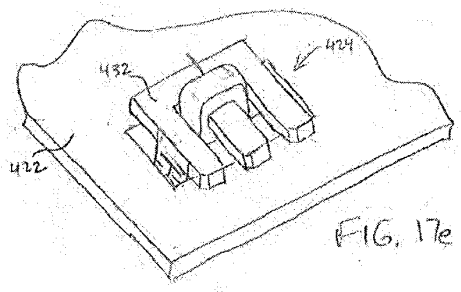


FIG. 17e

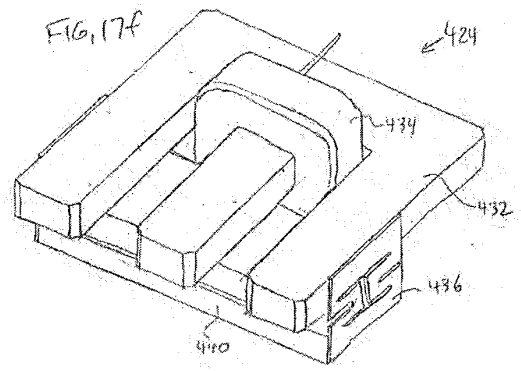


FIG. 17f

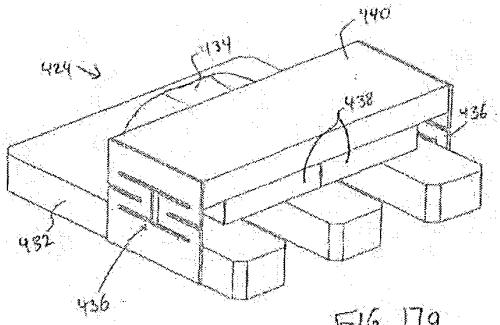


FIG. 17g

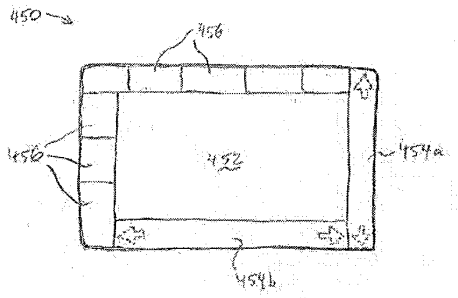


FIG. 18

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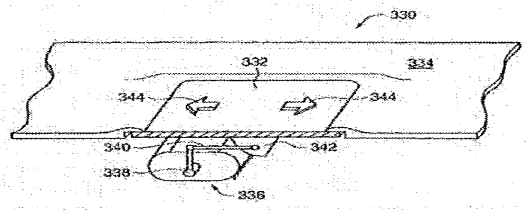
(74) Agent: LEMOND, Kevin, G.; Townsend and Townsend and Crew LLP, Two Embarcadero Center, 8th Floor, San Francisco, CA 94111 (US).

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[Continued on next page]

(54) Title: HAPTIC INTERFACE FOR LAPTOP COMPUTERS AND OTHER PORTABLE DEVICES



(57) Abstract: A haptic feedback interface device for providing input to a computer. A host computer device includes a planar touch surface that provides position information to a user object based on locations of user contact. The computer can position a cursor in a displayed graphical environment based on such information, or perform a different function. At least one actuator (330) is coupled to the touch surface and outputs forces to provide a haptic sensation to the user. The actuator (330) can move the touch pad (332) linearly, or a separate surface member can be included. A flat D-core actuator, piezoelectric actuator, or other types of actuators can be used to provide forces. The touch pad device can include multiple different regions to control different computer functions.

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HAPTIC INTERFACE FOR LAPTOP COMPUTERS AND OTHER PORTABLE DEVICES

BACKGROUND OF THE INVENTION

The present invention relates generally to the interfacing with computer and mechanical devices by a user, and more particularly to devices used to interface with computer systems and electronic devices and which provide haptic feedback to the user.

Humans interface with electronic and mechanical devices in a variety of applications, and the need for a more natural, easy-to-use, and informative interface is a constant concern. In the context of the present invention, humans interface with computer devices for a variety of applications. One such application is interacting with computer-generated environments such as games, simulations, and application programs. Computer input devices such as mice and trackballs are often used to control a cursor within a graphical environment and provide input in these applications.

In some interface devices, force feedback or tactile feedback is also provided to the user, collectively known herein as "haptic feedback." For example, haptic versions of joysticks, mice, gamepads, steering wheels, or other types of devices can output forces to the user based on events or interactions occurring within the graphical environment, such as in a game or other application program.

In portable computer or electronic devices, such as laptop computers, mice have typically too large a workspace to be practical. As a result, more compact devices such as trackballs are often used. Currently, a more popular device for portable computers are "touchpads," which are small rectangular, planar pads provided near the keyboard of the computer. The touchpad senses the location of a pointing object by any of a variety of sensing technologies, such as capacitive sensors or pressure sensors that detect pressure applied to the touchpad. The user contacts the touchpad most commonly with a fingertip and moves his or her finger on the pad to move a cursor displayed in the graphical environment. In other embodiments, the user can operate a stylus in conjunction with the touchpad by pressing the stylus tip on the touchpad and moving the stylus. Touchscreens are similar devices used to input information on a sensing pad layered on a display screen, and are used in such devices as personal digital assistants (PDA's) and other portable electronic devices.

One problem with existing touchpads and screens is that there is no haptic feedback provided to the user. The user of a touchpad is therefore not able to experience haptic sensations that assist and inform the user of targeting and other control tasks within the

graphical environment. The touchpads of the prior art also cannot take advantage of existing haptic-enabled software running on the computer.

SUMMARY OF THE INVENTION

The present invention is directed to haptic feedback planar touch controls used to provide input to a computer system. The control can be a touchpad provided on a portable computer, or can be a touch screen found on a variety of devices. The haptic sensations output on the touch control enhance interactions and manipulations in a displayed graphical environment or when controlling an electronic device.

More specifically, the present invention relates to a haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control. The control includes a touch input device including an approximately planar touch surface operative to input a position signal to a processor of said computer based on a location of user contact on the touch surface. One or more actuators are coupled to the touch input device which can output a force to laterally move the touch input device approximately parallel to its surface to provide a haptic sensation to the user contacting it. The computer can position a cursor in a graphical environment displayed on a display device based on the position signal. The touch input device can be a separate touchpad or included as a touch screen.

In another embodiment, a haptic feedback touch control includes a touch input device including an approximately planar touch surface which inputs a position signal to a computer processor, a surface member located adjacent to the touch input device, where the user can contact the surface when pressing the touch input device, and an actuator coupled to the surface member. The actuator outputs a force on the surface member to provide a haptic sensation to the user. The surface member can be translated laterally, approximately in a plane parallel to the surface of the touch input device; for example, the surface member can be positioned over the touch input device and coextensive with the device surface, or the surface member can be positioned to a side of the touch input device such that the user touches the touch input device with one finger and touches the surface member with a different finger or palm. For example, the surface member can be positioned over a physical button that is located adjacent to said touch input device. Contact or inertial forces can be output on the surface member.

In another aspect of the present invention, an actuator providing a linear force output includes a ferromagnetic plate including a center pole located between two side poles, a coil wrapped around the center pole, a magnet adjacent to the center pole and side poles, and a backing plate coupled to the magnet, where the backing plate and magnet move with respect to

the ferromagnetic piece when current is flowed in the coil. Rollers can be positioned between the ferromagnetic piece and backing plate to allow the motion. A flexure can reduce the relative motion between plate and ferromagnetic piece in undesired directions and provide a spring centering force.

In another aspect, a haptic touch device includes a piezoelectric transducer coupled to a ground and including a metal diaphragm coupled to a ceramic element and a planar sensing element, such as a touchpad. A spacer is provided between the piezoelectric transducer and the planar sensing element, the metal diaphragm contacting the spacer. A spring element provides a spring restoring force to the planar sensing element.

In another aspect of the present invention, a method for providing haptic feedback to a touch input device includes receiving a position signal from the touch input device indicating a contact location on a surface where said user is pressing, and determining in which of a plurality of regions on the surface the contact location is positioned. An output force is associated with the user moving an object on or over the surface of the touch input device. A function can be associated with the region in which the contact location is positioned, such as rate control function of a value or moving a displayed cursor. The can be output when the user moves the object over a boundary to the contacted region from a different region of the touch input device.

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 are also inexpensive, compact and consume low power, allowing them to be easily incorporated into a wide variety of portable and desktop computers and electronic devices.

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

FIGURE 1 is a perspective view of a laptop computer device including a haptic touchpad of the present invention;

FIGURE 2 is a perspective view of a remote control device including a touchpad of the present invention;

FIGURE 3 is a top plan view of a haptic touchscreen embodiment of the present invention;

FIGURE 4 is a block diagram of a haptic system suitable for use in the present invention;

FIGURE 5 is a perspective view of one embodiment of an actuator assembly suitable for use in an inertial embodiment of the present invention;

FIGURE 6 is a perspective view of the actuator assembly of Fig. 5 coupled to a touchpad;

FIGURE 7 is a perspective view of a separate palm surface providing inertial tactile sensations adjacent to a touchpad;

FIGURE 8a is a perspective view of a piezoelectric transducer suitable for use in providing inertial sensations in the present invention;

FIGURE 8b is a side elevational view of a piezoelectric transducer and structure of the present invention suitable for providing haptic sensations with a touch device;

FIGURE 9 is a perspective view of one embodiment of a translating surface member driven by linear actuators;

FIGURE 10 is a top plan view of another embodiment of a translating surface member driven by a rotary actuator;

FIGURE 11 is a perspective view of another embodiment of a translating surface member driven by a voice coil actuator;

FIGURE 12 is a perspective view of an embodiment of a translating surface adjacent to a touchpad;

FIGURE 13 is a perspective view of an embodiment of a touchpad translated in one direction by a rotary actuator;

FIGURE 14 is a perspective view of an embodiment of a touchpad translated in two directions by rotary actuators;

FIGURES 15a and 15b are perspective views of a first embodiment of a flat E-core actuator of the present invention suitable for translating a touchpad or a separate surface;

FIGURE 15c is a side view of the actuator of Figs. 15a-15b;

FIGURE 15d is a perspective view of the actuator of Figs. 15a-15b coupled to a touchpad;

FIGURES 16a and 16b are top and bottom perspective views of another embodiment of a flat E-core actuator of the present invention;

FIGURES 17a-17b are perspective and top views of surface-mounted E-core actuators of the present invention;

FIGURES 17c-17g are perspective and side views of the E-core actuators of Figs. 17a-17b; and

FIGURE 18 is a top plan view of an example of a haptic touchpad of the present invention having different control regions.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIGURE 1 is a perspective view of a portable computer 10 including a haptic touchpad of the present invention. Computer 10 can be a portable or "laptop" computer that can be carried or otherwise transported by the user and may be powered by batteries or other portable energy source in addition to other more stationary power sources. Computer 10 preferably runs one or more host application programs with which a user is interacting via peripherals.

Computer 10 may include the various input and output devices as shown, including a display device 12 for outputting graphical images to the user, a keyboard 14 for providing character or toggle input from the user to the computer, and a touchpad 16 of the present invention. Display device 12 can be any of a variety of types of display devices; flat-panel displays are most common on portable computers. Display device 12 can display a graphical environment 18 based on application programs and/or operating systems that are running on the CPU of computer 10, such as a graphical user interface (GUI), that can include a cursor 20 that can be moved by user input, as well as windows 22, icons 24, and other graphical objects well known in GUI environments. Other graphical environments or images may also be displayed, e.g. a game, movie or other presentation, spreadsheet or other application program, etc.

Other devices may also be incorporated or coupled to the computer 10, such as storage devices (hard disk drive, DVD-ROM drive, etc.), network server or clients, game controllers, etc. In alternate embodiments, the computer 10 can take a wide variety of forms, including computing devices that rest on a tabletop or other surface, stand-up arcade game machines, other portable devices or devices worn on the person, handheld or used with a single hand of the user, etc. For example, host computer 10 can be a video game console, personal computer, workstation, a television "set top box" or a "network computer", or other computing or electronic device.

Touchpad device 16 of the present invention preferably appears externally to be similar to the touchpads of the prior art. In many embodiments disclosed herein, such a pad 16 includes a planar, rectangular (or other shaped) smooth surface that can be positioned below the keyboard 14 on the housing of the computer 10, as shown, or may be positioned at other areas of the housing. When the user operates the computer 10, the user may conveniently place a fingertip or other object on the touchpad 16 and move the fingertip to correspondingly move cursor 20 in the graphical environment 18.

In operation, the touchpad 16 inputs coordinate data to the main microprocessor(s) of the computer 10 based on the sensed location of an object on (or near) the touchpad. As with many touchpads of the prior art, touchpad 16 can use capacitive, resistive, or a different type of sensing. Capacitive touchpads typically sense the location of an object on or near the surface of the touchpad based on capacitive coupling between capacitors in the touchpad and the object. Resistive touchpads are typically pressure-sensitive, where the pressure of a finger, stylus, or other object against the pad causes conductive layers, traces, switches, etc. in the pad to electrically connect. Some resistive or other types of touchpads can detect the amount of pressure applied by the user and can use the degree of pressure for proportional or variable input to the computer 10. Resistive touchpads typically are at least partially deformable, so that when a pressure is applied to a particular location, the conductors at that location are brought into electrical contact. Such deformability can be useful in the present invention since it can potentially amplify the magnitude of output forces such as pulses or vibrations on the touchpad as used in the present invention. Forces can be amplified if a tuned compliant suspension is provided between an actuator and the object that is moved. Capacitive touchpads and other types of touchpads that do not require significant contact pressure may be better suited for the present invention in some embodiments, since excessive pressure on the touchpad may in some cases interfere with the motion of the touchpad for haptic feedback. Other types of sensing technologies can also be used in the touchpad. Herein, the term "touchpad" preferably includes the surface of the touchpad 16 as well as any sensing apparatus included in the touchpad unit.

Touchpad 16 can operate similarly to existing touchpads, where the speed of the fingertip on the touchpad correlates to the distance that the cursor is moved in the graphical environment. For example, if the user moves his or her finger quickly across the pad, the cursor is moved a greater distance than if the user moves the fingertip more slowly. If the user's finger reaches the edge of the touchpad before the cursor reaches a desired destination in that direction, then the user can simply move his or her finger off the touchpad, reposition the finger away from the edge, and continue moving the cursor. This is an "indexing" function similar to lifting a mouse off a surface to change the offset between mouse position and cursor. Furthermore, many touchpads can be provided with particular regions that are each assigned to particular functions that can be unrelated to cursor positioning. Such an embodiment is described in greater detail below with respect to Fig. 18. In some embodiments the touchpad 16 may also allow a user to "tap" the touchpad (rapidly touch and remove the object from the pad) in a particular location to provide a command. For example, the user can tap or "double tap" the pad with a finger while the controlled cursor is over an icon to select that icon.

In the present invention, the touchpad 16 is provided with the ability to output haptic feedback such as tactile sensations to the user who is physically contacting the touchpad 16. Various embodiments detailing the structure of the haptic feedback touchpad are described in greater detail below. Some embodiments may move a device housing or separate moving surface, not the touchpad itself.

Using one or more actuators coupled to the touchpad 16 or an associated surface, a variety of haptic sensations can be output to the user who is contacting the touchpad (or housing or separate surface). For example, jolts, vibrations (varying or constant amplitude), and textures can be output. Forces output to the user can be at least in part based on the location of the finger on the pad or the state of a controlled object in the graphical environment of the host computer 10, and/or independent of finger position or object state. Such forces output to the user are considered "computer-controlled" since a microprocessor or other electronic controller is controlling the magnitude and/or direction of the force output of the actuator(s) using electronic signals.

In other embodiments, the touchpad 16 can be provided in a separate housing that is connected to a port of the computer 10 via a cable or via wireless transmission and which receives force information from and sends position information to the computer 10. For example, Universal Serial Bus (USB), Firewire, or a standard serial bus can connect such a touchpad to the computer 10.

One or more buttons 26 can also be provided on the housing of the computer 10 to be used in conjunction with the touchpad 16. The user's hands have easy access to the buttons, each of which may be pressed by the user to provide a distinct input signal to the host computer

12. Typically, each button 26 corresponds to a similar button found on a mouse input device, so that a left button can be used to select a graphical object (click or double click), a right button can bring up a context menu, etc. In some embodiments, one or more of the buttons 26 can be provided with tactile feedback.

Furthermore, in some embodiments, one or more moveable portions 28 of the housing of the computer device 10 can be included which is contacted by the user when the user operates the touchpad 16 and which can provide haptic feedback. Having a moveable portion of a housing for haptic feedback is described in U.S. Patent Nos. 6,184,868 and 6,088,019. In some embodiments, both the housing can provide haptic feedback (e.g., through the use of an eccentric rotating mass on a motor coupled to the housing) and the touchpad 16 can provide separate haptic feedback. This can allow the host to control two different tactile sensations simultaneously to the user; for example, a vibration of a low frequency can be conveyed through the housing to the user and a higher frequency vibration can be conveyed to the user through the touchpad 16. Each other button or other control provided with haptic feedback can also provide tactile feedback independently from the other controls.

The host application program(s) and/or operating system preferably displays graphical images of the environment on display device 12. The software and environment running on the host computer 12 may be of a wide variety. For example, the host application program can be a word processor, spreadsheet, movie, video or computer game, drawing program, operating system, graphical user interface, simulation, Web page or browser that implements HTML or VRML instructions, scientific analysis program, virtual reality training program or application, or other application program that utilizes input from the touchpad 16 and outputs force feedback commands to the touchpad 16. For example, many games and other application programs include force feedback functionality and may communicate with the touchpad 16 using a standard protocol/drivers such as I-Force®, FEELit®, or Touchsense™ available from Immersion Corporation of San Jose, California.

The touchpad 16 can include circuitry necessary to report control signals to the microprocessor of the host computer 10 and to process command signals from the host's microprocessor. For example, appropriate sensors (and related circuitry) are used to report the position of the user's finger on the touchpad 16. The touchpad device also includes circuitry that receives signals from the host and outputs tactile sensations in accordance with the host signals using one or more actuators. Some touchpads may be integrated with a printed circuit board (PCB) that includes some of these components and circuitry. In some embodiments, a separate, local microprocessor can be provided for the touchpad 16 to both report touchpad sensor data to the host and/or to carry out force commands received from the host, such commands including, for example, the type of haptic sensation and parameters describing the

commanded haptic sensation. Alternatively, the touchpad microprocessor can simply pass streamed data from the main processor to the actuators. The term "force information" can include both commands/parameters and/or streamed data. The touchpad microprocessor can implement haptic sensations independently after receiving a host command by controlling the touchpad actuators; or, the host processor can maintain a greater degree of control over the haptic sensations by controlling the actuators more directly. In other embodiments, logic circuitry such as state machines provided for the touchpad 16 can handle haptic sensations as directed by the host main processor. Architectures and control methods that can be used for reading sensor signals and providing haptic feedback for a device are described in greater detail in U.S. Patent No. 5,734,373.

In existing touchpad embodiments, such as those manufactured by Synaptics Corp., particular characteristics and features are provided. The standard surface material for a touchpad is textured Mylar, and typically any non-conductive object can be used on the touchpad surface and be detected, though textured surfaces are better when a user's finger is used to point. The touchpad can also sense through thin overlays. There is typically space available for the additional of haptic feedback components; for example, on a 40 x 60 touchpad, over half of the board can be available for haptic circuitry.

Many touchpads include a "palm check" feature, which allows the laptop to sense whether the user is contacting the touchpad with a finger or with a palm or other part of the hand. Since the user may only be resting his or her palm and not be intending to provide input, the palm check feature would ignore input that is determined to be provided by a user's palm. Basically, the palm check feature computes the contact area made by the conductive object (finger, palm, arm, etc.). If the contact area exceeds a certain threshold, the contact is rejected. This feature can be turned off in many embodiments.

FIGURE 2 is a perspective view of another embodiment of a device 30 which can include the active touchpad 16 of the present invention. The device can be a handheld remote control device 30, which the user grasps in one hand and manipulates controls to access the functions of an electronic device or appliance remotely by a user (such as a television, video cassette recorder or DVD player, audio/video receiver, Internet or network computer connected to a television, etc.). For example, several buttons 32 can be included on the remote control device 30 to manipulate functions of the controlled apparatus. A touchpad 16 can also be provided to allow the user to provide more sophisticated directional input. For example, a controlled apparatus may have a selection screen in which a cursor may be moved, and the touchpad 16 can be manipulated to control the cursor in two dimensions. The touchpad 16 includes the ability to output haptic sensations to the user as described herein, based on a

controlled value or event. For example, a volume level passing a mid-point or reaching a maximum level can cause a pulse to be output to the touchpad and to the user.

In one application, the controlled apparatus can be a computer system such as WebTV from Microsoft Corp. or other computing device which displays a graphical user interface and/or web pages accessed over a network such as the Internet. The user can control the direction of the cursor by moving a finger (or other object) on the touchpad 16. The cursor can be used to select and/or manipulate icons, windows, menu items, graphical buttons, slider bars, scroll bars, or other graphical objects in a graphical user interface or desktop interface. The cursor can also be used to select and/or manipulate graphical objects on a web page, such as links, images, buttons, etc. Other force sensations associated with graphical objects are described below with reference to Fig. 18.

FIGURE 3 is a top plan view of another computer device embodiment 50 that can include any of the embodiments of haptic devices of the present invention. Device 50 is in the form of a portable computer device such as "personal digital assistant" (PDA), a "pen-based" computer, "web pad," "electronic book", or similar device (collectively known as a "personal digital assistant" (PDA) herein). Those devices which allow a user to input information by touching a display screen or readout in some fashion are relevant to the present invention, as well as devices allowing button input. Such devices can include the Palm Pilot® from 3Com Corp. or similar products, pocket-sized computer devices from Casio, Hewlett-Packard, or other manufacturers, E-books, cellular phones or pagers having touch screens, laptop computers with touch screens, etc.

In one embodiment of a device 50, a display screen 52 positioned adjacent a housing 54 may cover a large portion of the surface of the computer device 50. Screen 52 is preferably a flat-panel display as is well known to those skilled in the art and can display text, images, animations, etc.; in some embodiments screen 52 is as functional as any personal computer screen. Display screen 52 can be a "touch screen" that includes sensors which allow the user to input information to the computer device 50 by physically contacting the screen 50 (i.e. it is another form of planar "touch device" similar to the touchpad 16 of Fig. 1). For example, a transparent sensor film can be overlaid on the screen 50, where the film can detect pressure from an object contacting the film. The sensor devices for implementing touch screens are well known to those skilled in the art.

The user can select graphically-displayed buttons or other graphical objects by pressing a finger or a stylus to the screen 52 at the exact location where the graphical object is displayed. Furthermore, some embodiments allow the user to "draw" or "write" on the screen by displaying graphical "ink" images 56 at locations where the user has pressed a tip of a stylus, such as stylus 57, or a finger or other object. Handwritten characters can be recognized by

software running on the device microprocessor as commands, data, or other input. In other embodiments, the user can provide input additionally or alternatively through voice recognition, where a microphone on the device inputs the user's voice which is translated to appropriate commands or data by software running on the device. Physical buttons 58 can also be included in the housing of the device 50 to provide particular commands to the device 50 when the buttons are pressed. Many PDA's are characterized by the lack of a standard keyboard for character input from the user; rather, an alternative input mode is used, such as using a stylus to draw characters on the screen, voice recognition, etc. However, some PDA's also include a fully-functional keyboard as well as a touch screen, where the keyboard is typically much smaller than a standard-sized keyboard. In yet other embodiments, standard-size laptop computers with standard keyboards may include flat-panel touch-input display screens, and such screens (similar to screen 12 of Fig. 1) can be provided with haptic feedback according to the present invention.

In some embodiments of the present invention, the touch screen 52 may provide haptic feedback to the user similarly to the touchpad 16 described in previous embodiments. One or more actuators can be coupled to the touchscreen, or movable surfaces near the touchscreen, in a manner similar to the embodiments described below. The user can experience the haptic feedback through a finger or a held object such as a stylus 57 that is contacting the screen 52.

The touch screen 52 can be coupled to the housing 54 of the device 50 by one or more spring or compliant elements, such as helical springs, leaf springs, flexures, or compliant material (foam, rubber, etc.), to allow motion of the screen approximately along the z-axis, thereby providing haptic feedback. The screen can also be provided with flexures or other couplings allowing side-to-side (x and/or y) motion, similar to the appropriate embodiments described below.

FIGURE 4 is a block diagram illustrating a haptic feedback system suitable for use with any of the described embodiments of the present invention. The haptic feedback system includes a host computer system 74 and interface device 72.

Host computer system 74 preferably includes a host microprocessor 100, a clock 102, a display screen 76, and an audio output device 104. The host computer also includes other well known components, such as random access memory (RAM), read-only memory (ROM), and input/output (I/O) electronics (not shown).

As described above, host computer 74 can be a personal computer such as a laptop computer, and may operate under any well-known operating system. Alternatively, host computer system 74 can be one of a variety of home video game console systems commonly connected to a television set or other display, such as systems available from Nintendo, Sega,

Sony, or Microsoft. In other embodiments, host computer system 74 can be an appliance, "set top box", or other electronic device to which the user can provide input. Computer 74 can also be a portable, hand-held computer such as a PDA, or can be a vehicle computer, stand-up arcade game, workstation, etc.

Host computer 74 preferably implements a host application program with which a user is interacting via interface device 72 which includes haptic feedback functionality. For example, the host application program can be a video game, word processor or spreadsheet, Web page or browser that implements HTML or VRML instructions, scientific analysis program, movie player, virtual reality training program or application, or other application program that may utilize input of mouse 12 and which outputs haptic feedback commands to the device 72. Herein, for simplicity, operating systems such as Windows™, MS-DOS, MacOS, Unix, Palm OS, etc. are also referred to as "application programs." Herein, computer 74 may be referred as providing a "graphical environment," which can be a graphical user interface, game, simulation, or other visual environment and can include graphical objects such as icons, windows, game objects, etc. Suitable software drivers which interface such software with computer input/output (I/O) devices are available from Immersion Corporation of San Jose, California.

Display device 76 can be included in host computer 74 and can be a standard display screen (LCD, CRT, plasma, flat panel, etc.), 3-D goggles, or any other visual output device. Audio output device 104, such as speakers, is preferably coupled to host microprocessor 100 to provide sound output to user. Other types of peripherals can also be coupled to host processor 100, such as storage devices (hard disk drive, CD ROM drive, floppy disk drive, etc.) other input and output devices.

Interface device 72 is coupled to the computer 74 by a bus 80, which communicates signals between device 72 and computer 74 and may also, in some embodiments, provide power to the device 72. In other embodiments, signals can be sent between device 72 and computer 74 by wireless transmission/reception. In some embodiments, the power for the actuator can be supplemented or solely supplied by a power storage device provided on the device, such as a capacitor or one or more batteries. The bus 80 can be bi-directional to send signals in either direction between host 74 and device 72. Bus 80 can be a serial interface bus, such as an RS232 serial interface, RS-422, Universal Serial Bus (USB), MIDI, or other protocols well known to those skilled in the art; or a parallel bus or wireless link.

Device 72 may be a separate device from host 74 with its own housing, or may be integrated with the host computer housing, as in the laptop computer of Fig. 1. Device 72 can include or be associated with a dedicated local processor 110. Processor 110 is considered local to device 12, where "local" herein refers to processor 110 being a separate processor from any

host processors in host computer system 14. "Local" also may refer to processor 110 being dedicated to haptic feedback and sensor I/O of device 12. Processor 110 can be provided with software instructions (e.g., firmware) to wait for commands or requests from computer host 74, decode the command or request, and handle/control input and output signals according to the command or request. In addition, processor 110 can operate independently of host computer 74 by reading sensor signals and calculating appropriate forces from those sensor signals, time signals, and stored or relayed instructions selected in accordance with a host command. Suitable microprocessors for use as local processor 110 include lower-end microprocessors as well as more sophisticated force feedback processors such as the Immersion Touchsense Processor. Processor 110 can include one microprocessor chip, multiple processors and/or co-processor chips, digital signal processor (DSP) capability, and/or logic, state machines, an ASIC, etc.

Processor 110 can receive signals from sensor 112 and provide signals to actuator 88 in accordance with instructions provided by host computer 74 over bus 80. For example, in a local control embodiment, host computer 74 provides high level supervisory commands to processor 110 over bus 20 (such as a command identifier and one or more parameters characterizing the tactile sensation), and processor 110 decodes the commands and manages low level force control loops to sensors and the actuator in accordance with the high level commands and independently of the host computer 74. This operation is described in greater detail in US Patent 5,734,373. In the host control loop, force commands are output from the host computer to processor 110 and instruct the processor to output a force or force sensation having specified characteristics. The local processor 110 reports data to the host computer, such as locative data that describes the position of the device in one or more provided degrees of freedom. The data can also describe the states of buttons, switches, etc. The host computer uses the locative data to update executed programs. In the local control loop, actuator signals are provided from the processor 110 to an actuator 88 and sensor signals are provided from the sensor 112 and other input devices 118 to the processor 110. Herein, the term "tactile sensation" refers to either a single force or a sequence of forces output by the actuator 18 which provide a sensation to the user. For example, vibrations, a single jolt, or a texture sensation are all considered tactile sensations. The processor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions. The processor may use sensor signals in the local determination of forces to be output on the user object, as well as reporting locative data derived from the sensor signals to the host computer.

In yet other embodiments, other hardware instead of processor 110 can be provided locally to device 72 to provide functionality similar to processor 110. For example, a hardware state machine incorporating fixed logic can be used to provide signals to the actuator 88 and receive sensor signals from sensors 112, and to output tactile signals.

In a different, host-controlled embodiment, host computer 74 can provide low-level force commands over bus 30, which are directly transmitted to the actuator 18 via processor 110 or other circuitry if there is no processor 110. Host computer 14 thus directly controls and processes all signals to and from the device 72, e.g. the host computer directly controls the forces output by actuator 88 and directly receives sensor signals from sensor 112 and input devices 118. Other embodiments may employ a "hybrid" organization where some types of forces (e.g. closed loop effects) are controlled purely by the local microprocessor, while other types of effects (e.g., open loop effects) may be controlled by the host.

Local memory 122, such as RAM and/or ROM, is preferably coupled to processor 110 in device 72 to store instructions for processor 110 and store temporary and other data. Memory 122 can also or alternatively be included on the processor 110. In addition, a local clock 124 can be coupled to the processor 110 to provide timing data.

Sensors 112 sense the position or motion (e.g. an object on a touchpad) in desired degrees of freedom and provides signals to processor 110 (or host 74) including information representative of the position or motion. Sensors suitable for detecting motion include capacitive or resistive sensors in a touchpad, contact sensors in a touchscreen, etc. Other types of sensors can also be used. Optional sensor interface 114 can be used to convert sensor signals to signals that can be interpreted by the processor 110 and/or host computer system 14.

Actuator(s) 88 transmits forces to the housing, manipulandum, buttons, or other portion of the device 72 in response to signals received from processor 110 and/or host computer 14. Device 72 preferably includes one or more actuators which are operative to produce forces on the device 72 (or a component thereof) and haptic sensations to the user. The actuator(s) are "computer-controlled", e.g., the force output from the actuators is ultimately controlled by signals originating from a controller such as a microprocessor, ASIC, etc. Many types of actuators can be used, including rotary DC motors, voice coil actuators, moving magnet actuators, E core actuators, pneumatic/hydraulic actuators, solenoids, speaker voice coils, piezoelectric actuators, passive actuators (brakes), etc. Some preferred actuator types are described below. Actuator interface 116 can be optionally connected between actuator 88 and processor 110 to convert signals from processor 110 into signals appropriate to drive actuator 88. Interface 116 can include power amplifiers, switches, digital to analog controllers (DACs), analog to digital controllers (ADCs), and other components, as is well known to those skilled in the art.

In some of the implementations herein, the actuator has the ability to apply short duration force sensation on the housing or manipulandum of the device, or via moving an inertial mass. This short duration force sensation can be described as a "pulse." The "pulse" can be directed substantially along a particular direction in some embodiments. In some

embodiments, the magnitude of the "pulse" can be controlled, the sense of the "pulse" can be controlled, either positive or negative biased; a "periodic force sensation" can be applied and can have a magnitude and a frequency, e.g. the periodic sensation can be selectable among a sine wave, square wave, saw-toothed-up wave, saw-toothed-down, and triangle wave; an envelope can be applied to the period signal, allowing for variation in magnitude over time. The wave forms can be "streamed" from the host to the device, , or can be conveyed through high level commands that include parameters such as magnitude, frequency, and duration.

Other input devices 118 can be included in device 72 and send input signals to processor 110 or to host 74 when manipulated by the user. Such input devices include buttons, dials, switches, scroll wheels, knobs, or other controls or mechanisms. Power supply 120 can optionally be included in device 72 coupled to actuator interface 116 and/or actuator 18 to provide electrical power to the actuator. Alternatively, power can be drawn from a power supply separate from device 72, or power can be received across bus 80. Also, received power can be stored and regulated by device 72 (and/or host 74) and thus used when needed to drive actuator 88 or used in a supplementary fashion.

The interface device 12 can be any of a variety of types; some embodiments are described further below. The touchpads or touchscreen described herein can be provided on a variety of types of devices, such as gamepads, joysticks, steering wheels, touchpads, spherical controllers, finger pads, knobs, track balls, remote control device, cell phone, personal digital assistant, etc.

Specific Embodiments

The present invention presents a variety of embodiments in which haptic feedback is provided to a user of a laptop computer or other portable computing device, and/or to the user of any computing device having a touchpad or similar input device.

Some embodiments are based on displacing the skin of a user's finger when it is in contact with a touchpad. These embodiments deliver high fidelity sensations while offering a good correlation between input and output right at the user's fingertip. Actuator and linkage solutions are described to drive any of the translation embodiments. Other embodiments are based on the stimulation of palm surfaces of the user that are normally in contact with the laptop computer 10. These surfaces can provide haptic sensations based on inertially coupled forces or translation of the palm surfaces. Translations of surfaces in plane with the upper surface of the touchpad or laptop (i.e. in the X and/or Y axes) are as effective at conveying haptic information as vibrations or displacements in the Z axis (those normal to the touchpad or

laptop upper surface). This can be important when the volumetric constraints of a laptop are considered.

In many of the embodiments described herein, it is also advantageous that contact of the user is detected by a touch input device. Since haptic feedback need only be output when the user is contacting the touch device, this detection allows haptic feedback to be stopped (actuators "turned off") when no objects are contacting the touch input device. This feature can conserve battery power for portable devices. If a local touch device microprocessor (or similar circuitry) is being used in the computer, such a microprocessor can turn off actuator output when no user contact is sensed, thus alleviating the host processor of additional computational burden until touch is again detected, when the actuator output is resumed.

In many preferred embodiments, haptics are added to a laptop computer or other device in a way that does not force the user to relearn how to control the laptop or force the manufacturer to stretch design and manufacturing too far from existing designs to provide the haptic content. For example, in laptop embodiments, as the user moves his or her finger across the touchpad, a cursor displayed on the laptop screen is correspondingly moved. Haptic effects can be output on the touchpad or other laptop component contacted by the user when the cursor interacts with a graphical object or area, when an event occurs, etc. In other applications, haptic effects can be output when events or interactions occur in a game or other application running on the laptop. Many types of actuators, sensors, linkages, amplification transmissions, etc. can be used with the present invention.

A touchpad surface, as manufactured currently, typically is coupled to a printed circuit board (PCB) that includes necessary electronics and standard connections for connecting and operating the touchpad in a laptop. Thus, when forces are applied to the touchpad, they are also applied to the PCB that is often directly coupled to the touchpad, e.g. underneath the touchpad.

The embodiments herein are designed with particular guidelines and characteristics. For example, the particular haptic experiences that feel compelling in a certain embodiment, the location where the tactile content is focused or located physically, the spatial correlation of the haptic feedback with the pointing of the user's finger on the touchpad, e.g. the feedback can be right under the finger , or originate somewhere in the case/housing of the laptop, the required force strength and power for compelling feedback, the way the user interacts with the device and effect on quality and content of the feedback (angle of finger contact, etc), and which actuators and mechanisms that can fit into the laptop form factor/housing are most desirable.

Preferably, existing haptic feedback software and drivers can be used with the embodiments described herein, such as TouchSense software from Immersion Corp. A

standardized module, such as a particular touchpad, that works for many different types of products is desirable, such as PDAs, laptops, cell phones, and remote controls.

The focus of these inventive embodiments is primarily on tactile feedback implementations, not kinesthetic force feedback embodiments. As described herein, there are two basic classes of tactile feedback as applied to the present invention: inertial haptic feedback and moving contact haptic feedback. Inertial feedback is generated using inertially coupled vibrations and is based on moving an inertial mass that is coupled to the housing/user through a compliant flexure, where the mass motions cause inertial vibrations in a surface contacted by the user. Moving contact feedback relates to directly moving a surface or member, with respect to an earth ground, against the user and usually is generated by creating small displacements of the user's skin.

The distinction between inertial and moving contact feedback can be made in terms of the actual mechanism used to provide information to the user. Both inertial and tactile stimulation cause displacement of the hand or finger tissue; the inertial feedback is coupled through some enclosure by the transmissibility of that enclosure and the compliance of whatever holds the enclosure. Moving contact feedback refers to a mechanism that is more direct in how it stimulates the user's tissue. Examples would be tactile dots or surfaces that shear the skin of the finger to cause sensation by locally deforming the finger or palm tissue. This distinction is made for the purposes of classifying two types of embodiments described below: inertial and surface translation.

A novel actuator, referred to as Flat-E herein, is described below and can be used in all of the embodiments herein and represents a class of very low profile, power efficient, high performance, planar actuators. A Flat-E actuator can achieve acceptable performance levels and approach the limited volume and form factor required for laptop and other device applications.

Inertial Embodiments

These embodiments move an inertial mass to cause inertial haptic feedback to the user, which is typically transmitted through an enclosure or mechanism such as a housing or other surface. In many cases, inertial mass does not impact any surfaces in its travel, although such impacts can alternatively be used to provide additional haptic effects.

FIGURE 5 is a perspective view of one embodiment 150 of an actuator assembly that can be used to provide inertial haptic sensations for touchpads and housings of devices of the present invention. Actuator assembly 150 includes a grounded flexure 160 and an actuator 155.

The flexure 160 can be a single, unitary piece made of a material such as polypropylene plastic ("living hinge" material) or other flexible material. Flexure 160 can be grounded to the housing of the device 12, for example, at portion 161.

Actuator 155 is coupled to the flexure 160. The housing of the actuator is coupled to a receptacle portion 162 of the flexure 160 which houses the actuator 155 as shown. A rotating shaft 164 of the actuator is coupled to the flexure 160 in a bore 165 of the flexure 160 and is rigidly coupled to a central rotating member 170. The rotating shaft 164 of the actuator is rotated about an axis A which also rotates member 170 about axis A. Rotating member 170 is coupled to a first portion 172a of an angled member 171 by a flex joint 174. The flex joint 174 is made very thin in the dimension it is to flex so that the flex joint 174 will bend when the rotating portion 170 moves the first portion 172a approximately linearly. The first portion 172a is coupled to the grounded portion 180 of the flexure by a flex joint 178 and the first portion 172a is coupled to a second portion 172b of the angled member by flex joint 182. The second portion 172b, in turn, is coupled at its other end to the receptacle portion 162 of the flexure by a flex joint 184.

The angled member 171 that includes first portion 172a and second portion 172b moves linearly along the x-axis as shown by arrow 176. In actuality, the portions 172a and 172b move only approximately linearly. When the flexure is in its origin position (rest position), the portions 172a and 172b are preferably angled as shown with respect to their lengthwise axes. This allows the rotating member 170 to push or pull the angled member 171 along either direction as shown by arrow 176.

The actuator 155 is operated in only a fraction of its rotational range when driving the rotating member 170 in two directions, allowing high bandwidth operation and high frequencies of pulses or vibrations to be output. A flex joint 192 is provided in the flexure portion between the receptacle portion 162 and the grounded portion 180. The flex joint 192 allows the receptacle portion 162 (as well as the actuator 155, rotating member 170, and second portion 172b) to move approximately linearly in the z-axis in response to motion of the portions 172a and 172b. A flex joint 190 is provided in the first portion 172a of the angled member 171 to allow the flexing about flex joint 192 in the z-direction to more easily occur.

By quickly changing the rotation direction of the actuator shaft 164, the actuator/receptacle can be made to oscillate along the z-axis and create a vibration on the housing with the actuator 155 acting as an inertial mass. In addition, the flex joints included in flexure 160, such as flex joint 192, act as spring members to provide a restoring force toward the origin position (rest position) of the actuator 155 and receptacle portion 172. In some embodiments, the stops can be included in the flexure 160 to limit the motion of receptacle portion 122 and actuator 155.

Other embodiments can provide other types of actuator assemblies to provide inertial sensations, such as a flexure that moves a separate inertial mass instead of the actuator itself. Or, an eccentric mass coupled to a rotating shaft of an actuator can be oscillated to provide rotational inertial tactile sensations to the housing. The eccentric mass can be unidirectionally driven or bidirectionally driven. Other types of actuator assemblies may also be used, such as a linear voice coil actuator, solenoid, moving magnet actuator, etc.

In one embodiment, an actuator assembly such as described above may be coupled to any of various locations of a laptop housing or other device housing and used to vibrate parts of the housing, relying on the transmission of vibrations through the product housing by the remotely mounted actuator module. The actuator assembly can be attached to different areas of the laptop housing or components to provide inertial haptic feedback when the inertial mass is oscillated.

The experience of the user may vary depending on the precise location of the actuator assembly on the laptop and with different tactile effects that are output. Locations for the coupling of the actuator assembly include the housing bottom, side, or front, a surface engaged by the user's palm when operating the device, an area adjacent to the touchpad or touchscreen, or coupled to the touchpad or touchscreen. An effective location may be the touchpad itself (e.g. coupling the actuator assembly to the bottom of the touchpad). In some embodiments, if the touchpad is rectangular, more compliance may be achieved along the long axis of the touchpad.

In general, haptic content is received by the user over a limited frequency range by attaching the actuator assembly to a location on the laptop. A particular location most effective for transmitting vibrations can be determined by experimentation, for example.

In many cases, the output of several types of haptic effects can be faint and muddy to the user, and effects having predominantly higher frequencies may be more perceptible. One effective tactile effect for this embodiment is a relatively high frequency "ringing" effect. Sympathetic vibrations in the laptop case and the touchpad may amplify these vibrations. An actuator designed to resonate at a certain ideal frequency may be used to present a wide spectrum of frequencies by amplitude modulation techniques. For example, a compelling 25 Hz square wave can be generated by modulating a 250 Hz natural frequency generated by a tuned resonant actuator such as a large piezo ceramic resonator (see Figs. 8a-8b). Such modulation schemes may rely on the actuator being tuned to the environment it lives in and the object it must drive. Some type of vibration isolation system can be used in some embodiments to keep the energy confined to the haptic module as opposed to allowing the energy to dissipate off into sympathetic modes in other portions of the laptop computer or other device.

FIGURE 6 is a perspective view of another embodiment, in which a touchpad module can be suspended in a compliant support structure and can be coupled to a harmonic source and vibrated along the Z-axis. In this example, a touchpad 200 can be moved with an actuator assembly 202 that moves the touchpad surface in the Z-axis, perpendicular to the surface of the touchpad. The touchpad can be coupled to the laptop housing 204 by one or more layers or supports of foam, rubber, or other compliant material, where a strip 206 of foam provided around the perimeter of the touchpad between the touchpad 200 and the housing 204 as shown in Fig. 6. The actuator assembly 202 can be coupled to the bottom of the touchpad assembly (or to another location) so that when the inertial mass is oscillated, the oscillations transfer to the touchpad and allow it move in the Z-direction with respect to the laptop housing 204. For example, the actuator assembly can be bonded directly to the bottom of the touchpad PCB. A floating assembly of a touchpad and a bezel (surface surrounding the touchpad) can alternatively be moved, as opposed to just moving the touchpad module in the Z-axis.

In another embodiment, a stand-alone touchpad device can be used, where the touchpad is housed in a separate housing and communicates with the laptop or other device via wires or transmissions. In one embodiment, the stand-alone touchpad device can be attached to a palm pad (or other member), with the actuator assembly coupled to the pad. When the inertial mass of the actuator assembly is oscillated, the inertial sensations are transmitted through the member to the touchpad, i.e. this effectively provides inertial coupling from the actuator assembly to the touchpad surface. A foam layer (or other compliant layer) can be coupled between the pad and ground to provide compliance and allow the pad and touchpad to move inertially. This embodiment may feel more compelling than the embodiments in which the actuator assembly is mounted to the laptop near or on the built-in touchpad, possibly due to the compliance of the foam which can allow stronger sensations to be output.

The entire touchpad can be provided with haptic sensations as a single unitary member, or, in other embodiments, individually-moving portions of the pad can each be provided with its own haptic feedback actuator and related transmissions so that haptic sensations can be provided for only a particular portion. For example, some embodiments may include a touchpad having different portions that may be flexed or otherwise moved with respect to other portions of the touchpad.

In another embodiment, the surface around or adjacent to the touchpad is coupled to harmonic vibration source (e.g., actuator assembly) and vibrates in one or more axes. For example, palm rest surfaces may be driven by an inertial actuator assembly housed in the laptop. FIGURE 7 is a perspective view of one example of an inertially-driven palm rest surface. A laptop computer 210 includes a touchpad 212 that functions like a typical touchpad. A palm rest surface 214 is positioned adjacent to the touchpad 212, where the surface 214 can

be attached to the laptop housing on a layer of resilient open cell foam or other compliant material. In some embodiments, the surface 214 can be textured with divots and/or bumps to allow a stronger contact by the user to the surface. An actuator assembly 216 is coupled to the palm rest surface 214; in the embodiment shown, the assembly 216 is coupled to the underside of the surface 214. The assembly can be any of the actuator assemblies described above. For example, the actuator assembly 216 can provide z-axis oscillations to the palm rest surface 214.

The user preferably rests a palm and/or some fingers on the palm rest surface 214 while the user is using the touchpad 212 with a pointing finger(s). Thus, the user is able to feel haptic sensations through the palm rest surface while operating the touchpad. Alternatively, one hand of the user is used to point and operate the touchpad, while the other hand rests on the palm surface 214 and senses haptic feedback. The palm surfaces are implemented as practically unavoidable contact surfaces and consequently a user is not likely to miss very many haptic events while using the touchpad. In some embodiments, how hard the user rests the palms on the surface can make a slight difference in perceived magnitude over the useful bandwidth, and may be a result of stiffness and mass of the particular device used. The stiffness of the coupling of the palm surface with the housing can be adjusted for a particular feel in different embodiments.

In a related embodiment, the actuator assembly can be mounted in different areas. For example, the actuator assembly can be attached to the bottom of an extension of a palm rest surface made of textured material mounted on a layer of resilient open cell foam or other compliant material.

In other embodiments, the palm surface can be translated in the X and/or Y directions, similarly to the touchpad translation described below. The inertial actuator assembly could be used to force the translation, or a different type of actuator, e.g. high actuator authority and fairly high stiffness in the translation mode to avoid unintentional hard stop limiting distortion, etc. The translating palm surface can be suitable for a flat actuator so that the assembly can be integrated into the laptop housing; flat actuators are described below.

FIGURE 8a is a perspective view of an actuator that can be used in another embodiment of an inertial haptic feedback device of the present invention. In this embodiment, a higher frequency mechanical oscillator, mechanically coupled to the touchpad, is modulated. One example of such an implementation may include a large-diameter commercially available thin piezoelectric transducer 230, e.g., 60mm in diameter with natural frequencies of 300 to 400 Hz when supported peripherally. The piezoelectric transducer preferably includes a thin diaphragm (sheet) of metal 231. One embodiment may include an added mass 232 at the ceramic center of the piezo diaphragm in order to add inertial mass and lower the natural frequency to achieve stronger inertial tactile sensations from the oscillating mass. The outer periphery of transducer

230 can be grounded and the mass 232 can oscillate normal to the disc surface to create inertial haptic sensations to the housing to which the transducer is attached.

Actuator 230 can function as a harmonic oscillator that runs at a relatively high frequency that transmits sensations to the hand or part of the laptop to which it is attached. Amplitude modulation (envelope control) may be used to produce a wider haptic spectrum than the single fundamental drum mode. Large diameter piezo drivers are available, for example, from Kinogami of Taiwan. Differently sized discs can also be used.

To provide the desired haptic sensations, a large piezo transducer or "buzzer" should provide large sustainable displacements (accelerations) of the mass and the carrier frequency (the frequency at which it oscillates) should be modulated with the haptic signal. Some electronics may be needed to operate this type of actuator. A high voltage supply can be generated from 5 volts. An oscillation circuit, e.g., self exciting, can drive the element. There can be a gating feature to start and stop the oscillation as well as a proportional control to allow modulation of the amplitude of the output. An all-digital implementation may be provided by gating the oscillator on and off.

FIGURE 8h is a side elevational view of another embodiment 234 of a piezoelectric transducer providing haptic feedback, where the transducer applies (non-inertial) vibrations directly to the touchpad (or touchscreen) along the z-axis. A housing 236 of the laptop or other device can include bezels which overlay a touchpad member 238, which the user physically contacts to provide input to a computer or processor. The touchpad member 238 can include the required electronics to interface the touchpad with other electronic components. The touchpad member 238 can rest on a spacer 240 having a particular mass chosen to allow efficient haptic output. The spacer 240 rests on the edge of a piezo metal diaphragm 231, which is part of the piezo transducer, and where an electrical lead 241 is coupled between the diaphragm 231 and a signal source 246. The piezo ceramic element 242, also part of the piezo transducer, is coupled to the metal diaphragm 231 and an electrical lead 243 is coupled between the element 242 and the signal source 246. A conductive electrode is plated on the ceramic element 242. A contact pad 248 is positioned between the element 247 and a bottom housing 250, where the contact pad is rigidly coupled to both ceramic element 242 and housing 250. The contact pad 248 is made small so that the diaphragm 231 will have increased bending, resulting in greater acceleration and stronger haptic effects. The bottom housing 250 can include a printed circuit board (PCB), for example. One or more preloaded spring elements 252 couple the touchpad member 238 to the bottom housing 250, e.g. leaf springs, helical springs, etc.

In operation, the piezo transducer moves along the z-axis when an oscillating current from signal source 246 is flowed through the diaphragm 231 and the ceramic element 242.

Thus, spacer 240 is provided only at the edges of the diaphragm 231 to allow the inner portion of the diaphragm and the ceramic element 242 to move, and the ceramic element pushes against the bottom housing 250, causing the diaphragm 231 to push against the spacer 240, which in turn pushes against the touchpad element 238. This pushes the touchpad element up, and the spring elements 252 provide a spring return force on the touchpad so that it will return to its neutral position. When the piezo transducer similarly moves in the opposite direction, as directed by the oscillating signal, this moves the touchpad element 238 down toward the bottom housing 250. The touchpad element thus oscillates along the z-axis and provides haptic sensations to the user contacting the touchpad element.

In some embodiments, the components of the touchpad embodiment 234 can be chosen to provide more effective haptic sensations. For example, if the piezo transducer oscillates at close to a natural frequency of the mechanical system (including the transducer itself), then stronger forces and more effective haptic sensations can be output. The natural frequency of this moving mechanical system can be approximately expressed as the square root of the expression k1 plus k2 divided by m, as shown below:

$$fn = \sqrt{(k1 + k2 / m)}$$

where fn is the natural frequency, k1 is the spring constant of the metal diaphragm 231 of the piezo transducer, k2 is the spring constant of the spring elements 252, and m is the total mass of the spacer 240, the touchpad 238, and the parts of the suspension attached to the touchpad. This mass, as well as the spring constants, can be selected to provide a desirable low natural frequency, such as about 120 Hz or less, which tends to cause effective haptic sensations. The spacer 240 can allow multiple piezo transducers, e.g. positioned side by side, to be positioned against the bottom housing 250, so that the multiple transducers can be driven in unison for stronger haptic effects or at different times to provide sensations at particular locations of the touchpad element 238.

One way to provide the drive signal is to provide an initial oscillating carrier signal at or near the natural frequency fn, modulate the carrier signal with an effect envelope, if applicable (e.g. shape the amplitude to a desired configuration to provide a desired frequency or effect), and drive an amplifier with the modulated signal, which in turn drives the piezo transducer. A sine wave carrier signal, as opposed to square wave or other types, used in such an embodiment tends to produce quieter haptic effects in the described embodiment of Fig. 8b, which is often more desirable.

In an alternate embodiment, the piezoelectric transducer and spacer can be reversed in orientation so that the spacer 240 contacts the bottom housing 250, the diaphragm 231 rests on the spacer 240, the ceramic element 242 is positioned above the diaphragm, and the ceramic

element directly impacts the touchpad element 238 or a pad coupled to the touchpad member when it is oscillated by the driving signal. In yet other embodiments, the ceramic element can be directly coupled to the touchpad element, but in general less strong and effective haptic effects are the result.

Surface Translation Embodiments

These embodiments translate a surface that is in contact with the user to provide haptic feedback to the user. The user feels the translating surface in shear with his or her skin, creating an immediate sensation. This type of haptic feedback is based on either surface motion in-plane without interactions with fixed surfaces or relative motion between adjacent surfaces that are in contact with the users finger or hand. Both translation of a surface in contact with or adjacent to the touchpad module surface (Figs. 9-12), as well as displacement of the touchpad surface itself (Figs. 13-14) are embodiments described below, as well as actuators that may be used for either application (Figs. 15-17). Moving-surface inventions described in U.S. Patent No. 5,184,868 can also be applied.

Small (< 1 mm) displacements between adjacent surfaces provide good signal transmission into finger tissue. Enhanced surfaces may have a physical surface texture (bumps, roughness, etc.) and can be shaped to engage the user for any position or orientation. In some embodiments, small lateral translations (displacements under the finger tip between .25mm to 0.5mm) can be more effective than remote inertial vibrations or even out-of-plane (z-axis) vibrations right under the touchpad, e.g., inertial coupling can have a more remote and disconnected feeling in some embodiments.

Separate Surface Translation

Displacing a separate surface member positioned on top of a touchpad module is very effective at providing well-correlated feedback. The feedback feels sufficiently synchronized that clear surfaces may be translated above visual displays, as in PDAs or touch screens. Translation of other surfaces to the side or otherwise adjacent to the touchpad can also be performed in other embodiments.

FIGURE 9 is a perspective view of a first separate surface translation embodiment 250 in which a separate thin surface that is in sliding contact with the touchpad module is moved laterally under the finger. A translating surface member ("surface") 252 is positioned on top of and covering the fixed touchpad 254. Extension members 256a and 256b which are coupled to the translating surface 252 can be extended approximately perpendicularly in the x- and y-directions away from the touchpad 254. An actuator 258a and 258b can be coupled to each

associated extension member 256a and 256b, respectively. In the described embodiment, the actuators 258 are linear actuators outputting a linear force on the associated extension member 256, thereby moving the translating surface in the direction of the output force. For example, the actuators can be "E" core actuators. The bar pole magnet 259 is not shown on the actuator 258h to reveal the coil 260 under the ferromagnetic piece 382.

The sliding surface 252 can be any of a variety of stiff or substantially stiff materials; for example, Kapton (polyamid) flexible printed circuit board material can be used. The extension members 256 can incorporate a stiffener section to prevent buckling. The sliding surface 252 can be a textured surface that provides a friction force to engage the user skin tissue in contact with the surface. A region on the top of the moving surface 252 can include the texture having sufficient surface roughness to provide purchase on the skin without feeling rough to touch. On the underside of the moving surface, a low friction coating can be included to promote sliding between surface 252 and touchpad 254. This underside component can be very thin, for example, less than 0.010 inches (.25 mm) thick.

The user points to and contacts the moving surface 252 just as if it were the touchpad 254 itself. The surface 252 is made thin enough so that the touchpad 254 can detect all the contact of the user to the surface 252 as if the user were touching the location of the touchpad directly underneath the location touched on the surface 252.

In some embodiments, the actuators can be located relatively far from the moving surface (e.g., >10cm) and in those cases the stiffer extension members 256 may need to transmit tension and compression with as little friction or out-of-plane movement as possible. Fiber laminations of glass or carbon can perform this function, for example.

In some moving magnet actuator embodiments, thin rare earth magnetic pieces can be laminated to the moving surface 252 to act as the moving magnets. A high level of integration can be achieved, for example, if the moving magnet pieces are on the order of < 1 mm in thickness and the "E" core and coil are located below the distal segments of the extensions 256, e.g., mounted directly to the touchpad PCB itself. The coil wires can be soldered directly to the touchpad PCB.

FIGURE 10 is a top plan view of another translating surface embodiment 270 in which a separate moving tactile surface is positioned above, and in sliding contact with, the touchpad. This surface is translated relative to the touchpad by a high bandwidth actuator through a high fidelity mechanical linkage.

In this embodiment, a translating surface 272 is positioned over a touchpad 274, similar to the embodiment of Fig. 9. An extension member 276 can protrude in a direction (x-direction

here) towards a rotary actuator 278, which in this example is grounded to the laptop housing 280. The actuator 278 can be a DC rotary motor having a rotatable shaft 282 that is coupled to a coupling linkage 284 that is in turn coupled to the extension member 276. For example, a portion of the linkage from the actuator assembly 150 described above can be used. When the actuator 278 rotates the shaft 282 in either direction, the linkage converts the rotation to surface 272 translation in a corresponding direction (left or right). For example, a displacement of about +/- 1 mm can be achieved. The user feels the surface translation when moving a finger over the surface 272. Motor rotation can result in very clean high fidelity translation in the X axis. A DC motor design may work in a laptop given spare volume out at the sides or locations in the front of the enclosure or housing. A similar extension, linkage and motor can be provided in the y-direction to move the surface 272 in that direction. The input of the user is detected on the touchpad through the moving tactile surface.

The thin surface can be trimmed to fit inside the touchpad area with a small border all around. A rectangular extension can be cut out of a larger lamination to provide a fairly rigid strip that is driven with an actuator. This strip should be wide enough to allow the actuator to push on it in operation without the strip buckling.

As in the embodiment of Fig. 9, a smooth surface can be provided on the underside of surface 272 that contacts the touchpad to provide a smooth low-friction sliding interface with the touchpad plastic covering that the user's finger normally touches. The top side of the moving surface 272 can be made frictional to allow a good user grip, e.g. a texture like fine sandpaper. This can provide an excellent contact surface because it provides some mechanical bonding with the finger surface, but is not rough enough to feel rough to touch. Other embodiments can use a variety of types of friction surfaces. Other embodiments may also use flatter actuators, such as moving magnet actuators or voice coil actuators.

Two strips 286 of plastic or other material can be attached to the bezel surrounding the touchpad (i.e. the rim of the housing opening for the touchpad) and covering the edges of the surface 272 in order to constrain the moving surface 272 and keep it flat against and parallel to the touchpad 274.

The embodiments of Figs. 9 and 10 can provide compelling haptic sensations. Adding a surface above the touchpad does not substantially interfere with the sensor operation of the touchpad. A user can concurrently point and receive haptic feedback through motion of this surface relative to the fixed touchpad. It is simple for the user to provide input to the laptop or other electronic device when touching and moving a finger over the translation surface above the touchpad. In some embodiments, the moving surface can be held above, not in close contact with, the touchpad and so some compression by the user may be required to take the free play out and come into proximity with the sensor array.

When moving a cursor over displayed scroll bars and around on the desktop GUI displayed by the laptop, the user feels distinct, high fidelity effects that are well correlated spatially with the cursor. The character of the correlation may be different depending on whether the user moves a finger or object in the x- or the y-axis. The actuator in the shown embodiment 270 moves the surface 272 in the x-axis. Consequently, moving the cursor up and down over icons, the user may feel pops or similar tactile effects as unidirectional if the user does not concentrate on or observe that the motion of the surface 272 is perpendicular to the cursor motion.

Motion of the user's finger in the translated direction – the x-axis in the example of Fig. 10 – tends to be more compelling. For example, as the user drags a finger in the x-direction to move a cursor from one displayed radio button to the next, the surface 272 may lead the user into the next button and can feel like a detent even though very small motions of the surface are being generated. A surface translation force opposing the direction of motion can be effective, e.g. if the user is moving left onto an icon, a translation force directed to the right feels crisp and natural. If haptic feedback is allowed in only one axis, the y-axis may be a better choice in some embodiments because there may be more vertically-oriented content on a GUI desktop and in applications.

A short, distinct pulse can provide excellent transitions when moving the cursor from one object to another, such as between graphical buttons. Vibrations can be conveyed to the user in surface translation embodiments by oscillating the actuator driving the surface, e.g. with a sine or other periodic wave, and thereby oscillating the translating surface in opposite directions.

The user also may naturally tend to take his or her finger off of the touchpad between motions that control the cursor, and an inherent spring centering of the motor and linkage can return the moving surface 252 or 272 to a neutral (origin) position, ready for the next interaction. The controlled cursor is not moved while the feedback apparatus has moved back to the neutral origin position, since only the surface above the touchpad moves and does not provide input to the computer through the touchpad like a user's finger.

Motion in a particular direction allows the surface translation embodiments to act in some embodiments as a relative pointing device with local pseudo-kinesthetic feedback. Tactile feedback is still the primary type of haptic feedback provided in such an embodiment, but the small displacements of the surface can be dramatically perceived as directed spring forces acting in such a way that they feel like detent "slopes" that force the user's finger in a direction, even though they are just pops.

The overall stiffness of the actuator can affect results. If the user presses too strongly on the moving surface, then the user may move the surface while dragging / pointing the finger and this can run the actuator out of its spring center. A preferred embodiment has a forceful but stiff actuator, one that the user can barely back-drive by pressing strongly.

Having particular amount of travel or compliance on the moving surface, e.g. about 2 mm, is desirable in some embodiments. There is a strong spring centering from the motor and linkage, and moving the cursor between two objects, such as buttons in a GUI, can be very realistic because the user may perceive true kinesthetic force feedback until finger pressure is decreased and the finger is moved quickly across the screen in a relative mode. The haptic effects which are output are simple tactile pops, and no actual kinesthetic springs are providing force in the X or Y directions. However, the user senses that his or her finger is being pulled into an adjacent object, e.g. the next button.

It should be noted that kinesthetic force feedback is possible in a different embodiment. For example, if the user keeps his or her finger in one place on the moving surface, and the moving surface has a large enough displacement, forces can be output in the degrees of freedom of motion of the moving surface, providing kinesthetic force feedback. The sensor of the touchpad can be used as the sensor indicating the position of the finger/moving surface for computation of the force, such as a spring force having a magnitude dependent on the distance that is moved from an origin of the spring. Thus, such an embodiment would be a dual mode haptic system, including both tactile and kinesthetic modes.

Some embodiments of the moving surface may allow sliding by the user, while others may be very stiff with little sliding. In many embodiments, if the maximum permitted movement of the surface is enough to allow traversal between two adjacent graphical targets, then the kinesthetic mode can be effective and user may not notice that he or she is moving the surface. Some embodiments can provide translation and forces in two axes (X and Y), allowing this kinesthetic directed feedback (real springs) in all directions of the touchpad.

Haptic effects may not feel the same if the user is not moving his or her finger or object on the touchpad. There is often content and value in the correspondence of touchpad motion with the haptic effect (e.g., a detent pop effect). For example, it is effective when the user finger is moving and receiving the pop effect when the finger translates the moving surface to the transition point between the icons or buttons.

Many of the advantages described above for separate translating surfaces are also applicable to translating the touchpad surface, described in detail below.

FIGURE 11 is a perspective view of another embodiment 296 of a separate translating surface and moving coil actuator. In this embodiment, a frame 292 is positioned over the touchpad 294 of the device. Frame 292 includes a thin surface portion 296 which is located directly above the touchpad 294 and is thin enough to allow the user's contact on the portion 296 to be detected by the touchpad 294 underneath. Frame 292 also includes an integrated voice coil 298 which is part of a voice coil actuator 300. The coil 298 can be wire traces that are molded into the frame 292, which can be a PCB. The other parts of the actuator 300 include a stationary two-pole magnet 302 positioned over the coil 298 and grounded to the laptop housing, and a backing plate 304 made of steel, positioned on the other side of frame 292 and grounded to the housing, and used for a flux return path. The steel subassembly can be attached to the touchpad PCB itself, for example.

Thus, the magnetic fields of the magnet 302 and the current flowing through coil 298 interact to cause a linear force on the frame 298, which causes the frame and portion 296 to move as indicated by arrow 306. This provides haptic sensations to the user similarly to the separate translating surface embodiments described above. The housing can surround the entire frame except for an opening surrounding the portion 296 of the frame 292. In some embodiments, wires from the coil 298 can be connected to the touchpad PCB using a separate flex circuit finger that branches off of the moving frame 292.

FIGURE 12 is a perspective view of another embodiment 310 of a separate translating surface. In this embodiment, a surface surrounding the touchpad is translated in x- and/or y-direction with respect to the touchpad surface. Thumb surface 312 is positioned at the bottom side of the touchpad 314 and is rigidly coupled to a link member 295. Link member 316 is coupled to a flexible link 318, which is coupled to the rotatable shaft of an actuator 320 that is grounded to the laptop housing. When the actuator 320 rotates the shaft, the flexible link 318 moves the link member 316 linearly as indicated by arrow 322, which moves the thumb surface 312 linearly along the x-axis. The thumb surface 312 is shown in sliding contact with a standard button (not shown) which is directly underneath the surface 312.

The user can rest his or her thumb, palm, or finger on the thumb surface 312 while operating the touchpad in order to feel the haptic sensations. To press the button located underneath the thumb surface 312, the user simply presses down on the surface 312. Overall, the sensations tend to be similar to the sensations for the other translating surfaces described above. In other embodiments, the link member 316 can be much longer to allow desired placement of the actuator 320 in the housing of the laptop or other device.

One disadvantage is that there is no feedback to the user unless the user has a thumb, finger, or palm on the thumb surface area. The user may have to reach for other buttons to type and then lose the haptic experience. A larger surface 312 or palm pad extension can be used in

embodiments in which it may be difficult to keep the user's thumb on the surface 312 while using the same hand to point with the touchpad.

Touch Device Translation

These embodiments translate the touchpad (or touchscreen) surface itself rather than moving a separate surface. The user feels the translating touchpad moving laterally, in shear with his or her skin, creating an immediate sensation. The touchpad can be moved relative to a fixed surround, such as a laptop housing.

FIGURE 13 is a perspective view of one embodiment 330 providing a translating touchpad surface. Touchpad 332 is moved relative to a housing 334, such as a laptop or PDA housing, by an actuator 336. In the described embodiment, the actuator 336 is a rotary actuator, such as a DC motor, having a rotating shaft 338 that is coupled to a linkage 340. The linkage 340 is coupled to a bracket 342 at its other end, where the bracket 342 is coupled to the underside of the touchpad 332 module. The linkage includes joints and/or flexibility/compliance to allow the rotational motion of the shaft 338 to be converted to linear force on the bracket 342, thereby causing the touchpad 332 to move laterally as shown by arrows 344. For example, the linkage can be made of polypropylene, similar to the linkages of the actuator assembly of Fig. 5. The laptop housing can serve as a constraining structure for the moving touchpad module.

For example, a standard DC motor can be used for actuator 336 and a polypropylene linkage assembly for linkage 340. In one embodiment, the haptic feedback components can reside where optional components for the laptop are normally placed, such as an optional disc drive.

In other embodiments, the actuator 338 can be located remotely from the touchpad 332, e.g., wherever space is available in the housing as opposed to directly underneath the touchpad as illustrated in Fig. 13. Linkages can be used to locate the actuator(s) remotely from the touchpad, as shown in Fig. 14 below.

Translating the entire touchpad in one or two axes may be one good overall haptics approach. Very small displacements ($0.2\text{mm} < x < 0.5\text{mm}$) of the touchpad are desired to provide useful haptics. The power consumption for this embodiment when evaluated within a practical magnitude range can be less than the consumption of currently available inertial mice interface devices, which can receive all needed power over the interface to the host computer, such as USB.

Some advantages are apparent in this type of embodiment. Feedback experience is direct, well correlated with pointing, and precise. Implementation can be flexible and

unobtrusive, and addition of haptic components does not alter how the touchpad is used. The translating surface has a small displacement requirement compared with inertial approaches – this can lead to reduced power consumption and manufacturing benefits. In some embodiments, the motion of the touchpad can be oriented at an angle in the x-y plane. Some disadvantages may include use of a DC motor, which are relatively large, a flexible linkage may need a lot of clearance and may cause friction, and power consumption may be relatively high.

FIGURE 14 illustrates a perspective view of another embodiment 350 of a moving touchpad, in which the touchpad may be moved in both X and Y directions. The touchpad 351 is directly coupled to a first linkage member 351, which is coupled to a rotating shaft of an actuator 353 by a flexible member 354, such as polypropelene. Actuator 353 is grounded to the laptop housing. When actuator 353 rotates its shaft, the flexible member 354 converts the rotary motion to linear motion and translates the linkage member 352 in the x-direction, which in turn translates the touchpad as indicated by arrow 355. At the distal end of the first linkage member 354, a second linkage member 356 is coupled, e.g. by a flexible coupling.

A second actuator 358, grounded to the laptop housing, is coupled to the other end of the second linkage member 356 by a flexible member 357, where the axis of rotation of the rotating shaft of the actuator 358 is substantially the same as the axis of rotation of the actuator 353. The rotary force output by the rotating shaft of the actuator 358 is converted to a linear force by the flexible member 357. This linear force causes the second linkage member 356 to move linearly along its length, which in turn causes the first linkage member 352 to pivot approximately about its end near actuator 353 along the y-axis and cause the touchpad 351 to move approximately along the y-axis. The actuators 353 and 358 can be, for example, DC motors or any other type of actuator, e.g. linear actuators can also be used, as described below in Figs. 15-17. The linkage members can be made of any suitable material, e.g. carbon fiber. Preferably, very little energy is absorbed by the grounded structure or by unwanted deformations in the linkage assembly.

Thus, the mechanism decouples the x- and y-motions; by activating actuator 353, x-axis motion is provided, and by activating actuator 358, y-axis motion is provided; both x- and y-axis motion can be provided by activating both motors simultaneously. Both actuators can be driven either together (common mode) or differentially (differential mode) to achieve pure X or Y movement without binding the linkage parts. Furthermore, any combination of drive current will produce a resultant force along any arbitrary axis with the same fidelity and lack of binding.

One embodiment may use firmware for rapid evaluation and output of X and Y forces, e.g. software running on a local controller such as a microprocessor, or running off the host CPU. In some embodiments, such firmware may be too complex, so that alternatively, a

mechanism with an electronic way of switching between the two principle feedback axes can be used. In one embodiment, the two DC motors can be connected in a series circuit with switch that reverses the current through one of the two motors.

In the embodiment of Fig. 14, the user may feel the difference between x- and y-directional forces when moving a finger or object on the touchpad in the x-direction. There is haptic value in having the correlation or alignment of tactile feedback with finger/cursor motion; in some cases, alignment can boost the haptic signal-to-noise ratio. For example, moving the cursor right to fall over icons or buttons may feel better and more like real buttons to the user when the feedback is directed horizontally along the x-axis. Less power may be required overall if the feedback is aligned with the cursor direction instead of being omnidirectional or misaligned. In some cases, a weaker aligned haptic effect may be more meaningful than a stronger misaligned effect.

The touchpad surface with enhanced texture moves relative to a fixed surrounding surface with enhanced texture. The enhanced texture is more rough, corrugated, or otherwise textured, allowing a stronger user contact.

In some other embodiments, the touchpad surface can be comprised of interdigitated surface features that move relative to each other in x- and/or y- directions. For example, two halves of a touchpad can be driven by actuator(s) to move relative to each other.

In other embodiments, other actuators can be used to move the touchpad, touchscreen, or other touch device in the z-direction. For example, piezo-electric actuators, voice coil actuators, or moving magnet actuators can be directly coupled to the touchpad or touchscreen to provide direct motion of the touch surface. Also, the touchpad surface can be comprised of a fixed tactile surface and a reference surface, where the reference surface can displaced along the z-axis with respect to the fixed tactile surface.

FIGURES 15a and 15b are perspective views of the top side and bottom side, respectively, of a different embodiment of a novel "flat-E" actuator 360 for use in translating a touchpad. FIGURE 15c is a side view of the actuator 360. Actuator 360 is designed to be very flat and thus may be more appropriate to function within a flat assembly that can be inherently part of the touchpad, touchscreen, or other similar input device. "E-core" actuator topology provides an excellent actuator using minimal magnet material and delivers good force and bandwidth. One disadvantage of the moving magnet actuator is the large depth required ("E" core ferromagnetic piece width can be traded for height to some extent, perhaps reducing the overall depth of the actuator).

Actuator 360 presents a inventive embodiment of an "E" core that can be used to translate the touchpad (or alternatively to translate a separate surface, as in the embodiments of Figs. 9-14). A folded over, flat 3-D embodiment, shown in Figs. 15a-15b, that may behave substantially like a 2-D case, but with more leakage and non uniform flux at the poles.

Actuator 360 includes a ferromagnetic piece 362 shaped as an "E", which can be made of a metal such as a ferrous metal or carbon steel plate, and can be a single piece of metal or a lamination. A coil 364 of wire is wound about the central pole of the "E" of the ferromagnetic piece 362. A floating plastic cage 368 can be positioned on the ferromagnetic piece 362 and can include two or more rollers 370 positioned in apertures in the cage and oriented so that the rollers roll about axes parallel to the axis passing through the coil 364 about which the coil is wound. The cage can be plastic and is floating, i.e. unattached to other components, to allow the rollers to roll. A two-pole magnet 366 is positioned above the poles of the ferromagnetic piece 362 and cage 368 so that there is an air gap between magnet and ferromagnetic piece. The magnet 366 is coupled to the underside (in the orientation of the figures; other orientations are possible) of a backing steel piece 372 which is positioned on top of and contacting the rollers 370. The rollers thus set the nominal magnetic gap between the magnet and the ferromagnetic piece 362. The backing steel piece 372 can be rigidly coupled to the touchpad 373, as shown in FIGURE 15d, so that the touchpad, steel piece 372, and magnet 366 can translate relative to the ferromagnetic piece 362. For example, the magnet may in some embodiments be a two pole bonded neodymium wafer, and the steel parts may be stamped from single sheets about 1 mm thick. Additional rollers or foam can be used to support the end of the ferromagnetic piece opposite the magnet 366. The magnet, cage, and backing piece are located to the side of the "E" poles rather than at the front edge as in other E-core type actuators; this allows the actuator of the present invention to be made very flat for laptop and other portable device applications.

In operation, an electrical current is flowed through the coil 364, which causes magnetic flux to flow through the ferromagnetic piece in the direction of arrows 374. In reaction, the steel plate 372 moves in a direction along the axis indicated by arrow 376 (the direction is dependent on the direction of the current in the coil). The rollers 370 rotate to allow the steel plate 372 and magnet 366 to translate relative to the ferromagnetic piece 362. The floating cage 368 keeps the rollers from moving in undesired directions as they rotate. Also, the magnetic attractive normal forces which occur between ferromagnetic piece 362 and magnet 366 are reacted with the rollers 370. Other Flat-E related embodiments can include flexure and knife-edge suspensions to react (allow motion from) magnetic normal forces.

The flat E actuator embodiments described herein can be used to translate the touchpad (or touchscreen) or a separate surface member above or to the side of the touchpad. For

example, two flat-E actuators can be used in a configuration similar to that of Fig. 9 to drive the touchpad or surface member in two axes, x and y.

The actuator 360 can be made very thin in comparison with other actuators, e.g. the assembly can be made approximately 3 or 4mm thick, less than half as thick as other "E" core actuators. The magnetics design can be iterated for optimal performance. Linearity and detent forces can be traded for thickness.

Advantages include a planar, thin geometry, which is suitable for laptops, PDA, and other portable devices. The moving magnet approach does not require a large air gap so it may be more attractive for laptop haptic feedback. An "E" core prototype was 10mm X 20mm X 8mm and is smaller than most DC motors with equivalent force and power consumption. Furthermore, it is a direct drive configuration, so no transmission is required between actuator and touchpad. Efficient, low cost, and easy to manufacture components allow the actuator to be produced cheaply. The actuator is simple to integrate with existing touchpad PCB's and modules. One disadvantage is that magnetic attractive normal forces exist, which may necessitate a suspension. Rollers and/or flexure and knife edge suspensions can be used in some embodiments to react magnetic normal forces.

The actuator 360 generally provides good bandwidth. Larger (e.g., > 1mm) displacements can be achieved. Those embodiments employing foam to support the opposite end of the ferromagnetic piece have a return spring having a low spring constant, mostly from the foam suspension operated in shear mode. Audible noise may also be reduced by using the foam and/or rollers. While the haptic performance is good, the displacement of the surface is small enough so that when the user is moving a finger over the touchpad to move the cursor over the desktop, the surface displacement does not noticeably affect the cursor motion.

FIGURES 16a and 16b are perspective views of the top side and bottom sides of another embodiment 380 of the "flat-E" actuator of Figs. 15a-15c. A ferromagnetic piece 382 (or a lamination, in other embodiments) includes an approximate "E" structure and has a coil 384 wound around the E center pole 385. A two-pole magnet 386 is positioned across the E center pole 385 such that a gap is provided between ferromagnetic piece 382 and magnet, similarly to the embodiment 360. A metal plate 388 (e.g., steel) is coupled to magnet 386 and is provided parallel to the ferromagnetic piece and magnet. A cage 390 can be provided as the middle layer, where rollers 389 (shown as dashed lines) can be positioned within apertures in the cage 390 and allow the plate 388 to slide laterally with respect to the ferromagnetic piece and magnet. A touchpad or touchscreen (not shown) can be rigidly coupled to the top of plate 388, with piece 382 grounded. In alternate embodiments, the touchpad or touch screen can be coupled to the piece 382 with plate 388 grounded.

Embodiment 380 also includes a flexible suspension, which can be coupled to the middle layer plastic cage 390 and can include two linkages 392 that are thus effectively coupled between the steel plate 388 and the ferromagnetic piece 382. The linkages 392 contact the steel plate 388 at ends 394 and are coupled to the cage layer 390 at ends 396 (or molded with the cage layer as a single plastic piece). Each linkage includes a thinner portion 398 and a thicker portion 400.

In operation, a current is flowed through coil 384 and the magnetic forces resulting from the current and magnet 386 cause the plate 388 (and the touchpad) to move as indicated by axis 402. The suspension including linkages 392 prevents the plate 388 from showing due to magnetic normal forces and any other forces. Each linkage 392 flexes to accommodate the motion of the plate 388, where the thinner members 398 flex first, and the thicker members 400 flex if the limits of flex are reached for members 398. The thinner-thicker structure allows spring centering to operate until the thicker (stiffer) beams are engaged, which provide a softer feeling stop to motion. The final limit to motion is caused by either of the stops 404 hitting the inner edge of the plate 388.

The flexible suspension described above effectively allows lateral desired motion of the plate and touchpad, but prevent motion in any other direction. This creates a much more stable motion of the plate 388 and does not allow the plate 388 to drift in its position over time. Furthermore, the suspension provides a desirable spring centering force on the plate 388 and touchpad, allowing the touchpad to move to the center of its range of motion when the user stops touching and forcing the touchpad.

FIGURES 17a-17g are views illustrating another flat-E actuator touchpad embodiment 420 that miniaturizes this type of actuator and provides fabricated surface mount devices that take advantage of existing lead frame and over molding manufacturing technologies. Such small scale devices can be wave soldered onto the touchpad module and can work in parallel to provide suitable stroke and force for touchpad translation (or for z-axis forces in alternate embodiments).

Figures 17a-17c illustrate a top view of a PCB 422 which includes multiple Flat-E actuators 424. An actuator 424 can be positioned at each corner of the PCB 422 as shown. More or less actuators than shown can alternatively be placed in other configurations. The use of multiple actuators 422 can provide greater magnitude forces and allow each actuator 422 to have a lower force output and cost. In one embodiment, the PCB 421 is a separate PCB that is grounded to the housing of the laptop. The touchpad (e.g., including its own PCB different from PCB 422) is then coupled to the moving portions of the actuators, e.g., to the pads 426 shown in Fig. 17a. In another embodiment, the PCB 422 is the touchpad, and the moving portions of the actuators are coupled to a grounded surface in the laptop, such as the housing.

In such an embodiment, the actuators 424 can be hidden from the user by a lip of housing that extends around the perimeter of the touchpad, leaving the center area of the PCB 422 exposed to the user.

Fig. 17d is a side elevational view of one end of a PCB 422, separate from the touchpad, that includes the flat-E actuators 424. The touchpad/PCB member 428 is coupled to the moving portions 430 of the actuators 424.

Fig. 17e is a perspective view illustrating one embodiment of the underside of the PCB 422 shown in Fig. 17a, where the flat-E actuators 424 have been surface mounted to the underside of the PCB 422. This can be done as "hand-placed" components, or preferably using automatic surface mount technology placement equipment. The "E" ferromagnetic piece 432 can be grounded to the PCB 422 so that the magnet and steel backing plate of the actuator move.

Figs. 17f and 17g are perspective views illustrating top and bottom views, respectively, of the flat-E actuator 424 which has 3 poles and can operate similarly to the flat-E actuators described above. Ferromagnetic piece 432 is shaped like an "E" and has a coil 434 wrapped about the center pole. Flexures 436 allow the magnet 438 and steel backing plate 440 to move relative to the ferromagnetic piece 432 and coil 434. The touchpad (not shown) can be coupled to the steel backing piece 440 and the E-laminate piece 432/coil 434 can be grounded, as in the embodiments of Figs. 17a-17e. Alternatively, the backing piece 440 and magnet 438 can be grounded and the touchpad can be coupled to a moving ferromagnetic piece 432.

A flat-E actuator as described above can be used to translate touchpad modules or palm surfaces directly. In the described embodiments, the total thickness of the flat-E actuator can be about 3 mm or less. Flat-E magnetic assemblies that can be integrated into the an existing touchpad product line represent a preferred embodiment in terms of size, manufacturability and economy of scale.

In other embodiments, other moving magnet actuator designs, and other voice coil actuator designs, such as described in U.S. Patent Nos. 6,166,723 and 6,100,874, can be used.

In other embodiments, other types of input surfaces or display screens can be similarly translated using any of the actuators described herein. For example, a clear surface such as the input sensing device(s) covering a display screen of a personal digital assistant (PDA) or a touch screen on a monitor or CRT, can be similarly translated in the X and/or Y directions (parallel to the screen surface) to provide haptic feedback. One application for such clear screen translation is ATM machines, where the user typically inputs information on a touch screen. Haptic feedback can make such input more accessible and easy for people with below-

average vision. Haptic feedback can indicate when the user's finger is over a graphically-displayed button, or can identify particular displayed buttons with different haptic sensations. 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.

The embodiments described herein can also provide haptic feedback to 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

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. 16a-16b. 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.

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.

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).

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.

FIGURE 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 a 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.

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.

Another type of force sensation that can be output on the touchpad is a texture force. This type of force is similar to a pulse force, but depends on the position of the user's finger on the area of the touchpad and/or on the location of the cursor in a graphical environment. Thus, texture bumps can be output depending on whether the cursor has moved over a location of a bump in a graphical environment. This type of force is spatially-dependent, i.e. a force is output depending on the location of the cursor as it moves over a designated textured area; when the cursor is positioned between "bumps" of the texture, no force is output, and when the cursor moves over a bump, a force is output. This can be achieved by the host sending the pulse signals as the cursor is dragged over the grating, or, a separate touchpad processor can be dedicated for haptic feedback with the touchpad, and the texture effect and be achieved using local control (e.g., the host sends a high level command with texture parameters and the sensation is directly controlled by the touchpad processor). In other cases a texture can be performed by presenting a vibration to a user, the vibration being dependent upon the current velocity of the user's finger (or other object) on the touchpad. When the finger is stationary, the vibration is deactivated, as the finger is moved faster, the frequency and magnitude of the vibration is increased. This sensation can be controlled by the touchpad processor (if present), or the host. Other spatial force sensations can also be output. In addition, any of the described force sensations herein can be output simultaneously or otherwise combined as desired.

Different types of graphical objects can be associated with haptic sensations. Haptic sensations can output on the touchpad based on interaction between a cursor and a window, menu, icon, web page link, etc. For example, a "bump" or pulse can be output on the touchpad to signal the user of the location of the cursor when the cursor is moved over a border of a window. In other related interactions, when a rate control or scrolling function is performed with the touchpad (through use of the cursor), sensations can be output related to the rate control functions. Furthermore, the magnitude of output forces on the touchpad can depend on the event or interaction in the graphical environment, including user-independent events. These force sensations can also be used in games or simulations. These and other haptic sensations are described in U.S. Patent No. 6,211,861. Other control devices or grips that can include a

touchpad of the present invention in its housing include a gamepad, mouse or trackball device for manipulating a cursor or other graphical objects in a computer-generated environment, or a pressure sphere or the like.

Some forms of touchpads and touchscreens allow the amount of pressure the user is exerting on the touchpad to be sensed. This allows a variety of haptic sensations to be determined based at least in part on the sensed pressure. For example, a periodic vibration can be output having a frequency that depends on the sensed pressure. Or, the gain (magnitude) of output haptic sensations can be adjusted based on the sensed pressure. Those users that always tend to use the touchpad with more pressure can be allowed to select an automatic magnitude increase that would be in effect constantly.

Other embodiments of touchpads and touchscreens allow the user to enter "gestures" or shortcuts by making a symbol on the cursor control region or other region, which is recognized as a command or data by a processor. Haptic sensations can be associated with or dependent on particular gestures. For example, a confirmation of modes can be conveyed haptically with a particular haptic sensation when a mode confirmation gesture is recognized. Characters recognized from gestures also may each have a particular haptic sensation associated with them. In most touchpad embodiments, a user can select a graphical object or menu item by "tapping" the touchpad. Some touchpads may recognize a "tap-and-a-half" or double tap, which is the user doing a tap and then again touching the pad and maintaining the finger or object on the pad while moving the finger. For example, such a gesture can provide a "drag" mode in which objects may be moved with the cursor. When the user is in such a drag mode, a vibration or other haptic sensation can be output to indicate to the user that this mode is active.

As stated above, the touchpad 450 can also be provided with different control regions that provide separate input from the main cursor control region 452. In some embodiments, the different regions can be physically marked with lines, borders, or textures on the surface of the touchpad 450 (and/or sounds from the computer 10) so that the user can visually, audibly, and/or tactilely tell which region he or she is contacting on the touchpad.

For example, scroll or rate control regions 454a and 454b can be used to provide input to perform a rate control task, such as scrolling documents, adjusting a value (such as audio volume, speaker balance, monitor display brightness, etc.), or panning/tilting the view in a game or simulation. Region 454a can be used by placing a finger (or other object) within the region, where the upper portion of the region will increase the value, scroll up, etc., and the lower portion of the region will decrease the value, scroll down, etc. In embodiments that can read the amount of pressure placed on the touchpad, the amount of pressure can directly control the rate of adjustment, e.g., a greater pressure will cause a document to scroll faster. The region

454b can similarly be used for horizontal (left/right) scrolling or rate control adjustment of a different value, view, etc.

Particular haptic effects can be associated with the control regions 454a and 454b. For example, when using the rate control region 454a or 454b, a vibration of a particular frequency can be output on the touchpad. In those embodiments having multiple actuators, an actuator placed directly under the region 454a or 454b can be activated to provide a more localized tactile sensation for the "active" (currently used) region. As a portion of a region 454 is pressed for rate control, pulses can be output on the touchpad (or region of the touchpad) to indicate when a page has scroll by, a particular value has passed, etc. A vibration can also be continually output while the user contacts the region 454a or 454b.

Other regions 456 can also be positioned on the touchpad 450. For example, each of regions 456 can be a small rectangular area, like a button, which the user can point to in order to initiate a function associated with the pointed-to region. The regions 456 can initiate such computer functions as running a program, opening or closing a window, going "forward" or "back" in a queue of web pages in a web browser, powering the computer 10 or initiating a "sleep" mode, checking mail, firing a gun in a game, cutting or pasting data from a buffer, saving a file to a storage device, selecting a font, etc. The regions 456 can duplicate functions and buttons provided in an application program or provide new, different functions.

Similarly to regions 454, the regions 456 can each be associated with haptic sensations: for example, a region 456 can provide a pulse sensation when it has been selected by the user, providing instant feedback that the function has been selected. For example, a haptic sensation such as a pulse can be output when the user "taps" a finger or object on a region 456, 452, or 454 to make a selection. Similar to physical analog buttons that provide a range of output based on how far the button is pushed, one or more regions 456 can be an analog-like button by providing a proportional, stepped, or analog output based on the pressure the user is exerting on the touchpad.

Furthermore, the same types of regions can be associated with similar-feeling haptic sensations. For example, each word-processor related region 456 can, when pointed to, cause a pulse of a particular strength, while each game-related region 456 can provide a pulse of different strength or a vibration. Furthermore, when the user moves the pointing object from one region 454 or 456 to another, a haptic sensation (such as a pulse) can be output on the touchpad 450 to signify that a region border has been crossed. For example, a high frequency vibration which quickly decays to zero magnitude can be output when the pointing object enters a designated region. This can be valuable since it provides an indication of the borders to the regions 454 and 456 which the user would not otherwise know. This also allows region reconfiguration of size and/or location and allows the user to quickly learn the new layout

haptically. Regions can also be associated with "enclosures" which define areas in a graphical environment and the different haptic sensations which are output when the cursor enters, exits, and is moved within the enclosure and the particular borders having such haptic associations.

In addition, the regions are preferably programmable in size and shape as well as in the function with which they are associated. Thus, the functions for regions 456 can change based on an active application program in the graphical environment and/or based on user preferences input to and/or stored on the computer 10. Preferably, the size and location of each of the regions can be adjusted by the user or by an application program, and any or all of the regions can be completely removed if desired. Furthermore, the user is preferably able to assign particular haptic sensations to particular areas or types of areas based on types of functions associated with those areas, as desired. Different haptic sensations can be designed in a tool such as Immersion Studio™ available from Immersion Corp. of San Jose, CA.

It should be noted that the regions 454 and 456 need not be physical regions of the touchpad 450. That is, the entire touchpad surface need merely provide coordinates of user contact to the processor of the computer and software on the computer can designate where different regions are located. The computer can interpret the coordinates and, based on the location of the user contact, can interpret the touchpad input signal as a cursor control signal or a different type of signal, such as rate control, button function, etc. (e.g. a driver program can provide this interpreting function if desired). A touchpad microprocessor, if present, may alternatively interpret the function associated with the user contact location and report appropriate signal or data to the host processor (such as position coordinates or a button signal), thus keeping the host processor or software ignorant of the lower level processing. In other embodiments, the touchpad 450 can be physically designed to output different signals to the computer based on different regions physically marked on the touchpad surface that are contacted by the user, e.g. each region can be sensed by a different sensor or sensor array.

Any of these embodiments described herein which provide haptic feedback to the finger or object of the user that contacts the touchpad or touchscreen may be used with the regions of touchpad 450.

While this invention has been described in terms of several preferred embodiments, it is contemplated that alterations, permutations, and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. For example, many of the features described in one embodiment can be used interchangeably with other embodiments. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the present invention.

EX1002 - Page 1209

What is claimed is:

CLAIMS

1. A haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control, the touch control comprising:

a touch input device including an approximately planar touch surface operative to provide a position signal based on a location on said touch surface which said user contacts, said position signal representing said location in two dimensions; wherein said computer receives position information derived from said position signal; and

at least one actuator coupled to said touch input device, said actuator outputting a force on said touch input device to laterally move said touch input device approximately parallel to a surface of said touch input device to provide a haptic sensation to said user contacting said touch surface, wherein said actuator outputs said force based on force information output by said computer.

2. A haptic feedback touch control as recited in claim 1 wherein said computer positions a cursor in a graphical environment displayed on a display device based at least in part on said position signal.

3. A haptic feedback touch control as recited in claim 1 wherein said touch input device is a touchpad, said touchpad being separate from a display screen of said computer.

4. A haptic feedback touch control as recited in claim 1 wherein said touch input device is integrated in a housing of said computer.

5. A haptic feedback touch control as recited in claim 1 wherein said user contacts said touch surface with a finger of said user.

6. A haptic feedback touch control as recited in claim 1 wherein said user contacts said touch surface with a physical object held by said user.

7. A haptic feedback touch control as recited in claim 1 wherein said at least one actuator is a first actuator that outputs a first force in a first lateral direction approximately parallel to said surface of said touch input device, and further comprising a second actuator coupled to said touch input device and operative to output a second force on said touch input device in a second lateral direction approximately parallel to said surface and approximately perpendicular to said first lateral direction.

8. A haptic feedback touch control as recited in claim 1 wherein said actuator is a linear actuator that provides an output force in a linear degree of freedom, and wherein said actuator is coupled between said touchpad and a grounded housing.

9. A haptic feedback touch control as recited in claim 8 wherein said actuator is a rotary actuator that provides an output force in a rotary degree of freedom, said output force being converted to said linear force.

10. A haptic feedback touch control as recited in claim 8 wherein said actuator is an E-core actuator.

11. A haptic feedback touch control as recited in claim 10 wherein said actuator includes at least one roller allowing a backing plate of said actuator to slide relative to a magnet of said actuator.

12. A haptic feedback touch control as recited in claim 11 wherein said actuator includes a flexure providing a spring return force between said backing plate and said magnet.

13. A haptic feedback touch control as recited in claim 1 wherein said actuator oscillates said touch input device laterally.

14. A haptic feedback touch control as recited in claim 1 wherein said touch input device includes a plurality of different regions, wherein at least one of said regions provides said position signal and at least one other region provides a signal that is used by said computer to control a different function.

15. A haptic feedback touch control as recited in claim 14 wherein at least one of said regions is associated with a different haptic sensation output on said touch input device than another one of said regions.

16. A haptic feedback touch control as recited in claim 14 wherein a haptic sensation is output when said user moves a contacting object from one of said regions to another one of said regions.

17. A haptic feedback touch control as recited in claim 1 wherein said actuator is a first actuator, and further comprising at least one additional actuator coupled to said touch input device, wherein said actuators are E-core actuators that have been surface mounted to a printed circuit board.

18. A haptic feedback touch control for inputting signals to a computer and for outputting forces to a user of the touch control, the touch control comprising:

a touch input device including an approximately planar touch surface operative to provide a position signal based on a location on said touch surface which said user presses, said position signal representing said location in two dimensions, wherein said computer receives position information derived from said position signal;

a surface member located adjacent to said touch input device, wherein said user can contact said surface when pressing said touch input device; and

at least one actuator coupled to said surface member, said actuator outputting a force on said surface member to provide a haptic sensation to said user contacting said surface member, wherein said actuator outputs said force based on force information output by said computer.

19. A haptic feedback touch control as recited in claim 18 wherein said surface member is translated laterally, approximately in a plane parallel to said planar touch surface.

20. A haptic feedback touch control as recited in claim 19 wherein said surface member is positioned over said touch input device and at least approximately coextensive with said surface of said touch input device, such that said user presses said surface member to press said touch input device.

21. A haptic feedback touch control as recited in claim 20 wherein said actuator is a linear actuator.

22. A haptic feedback touch control as recited in claim 20 wherein said actuator is a rotary actuator, wherein a linkage converts a rotary output force to an approximately linear output force on said translated surface member.

23. A haptic feedback touch control as recited in claim 18 wherein said actuator is a voice coil actuator, wherein a wire coil is physically coupled to said surface member.

24. A haptic feedback touch control as recited in claim 18 wherein said surface member is positioned to a side of said touch input device such that said user touches said touch input device with one finger and touches said surface member with a different finger or palm.

25. A haptic feedback touch control as recited in claim 21 wherein said surface member is positioned over a physical button that is located adjacent to said touch input device.

26. A haptic feedback touch control as recited in claim 18 wherein said force on said surface member is a linear force output approximately perpendicularly to a surface of said surface member.

27. A haptic feedback touch control as recited in claim 26 wherein said linear force is an inertial force output by an actuator assembly that includes said actuator and moves an inertial

45

mass, wherein said inertial force is transmitted through said surface member to said user contacting said surface member.

28. A haptic feedback touch control as recited in claim 18 wherein said surface member is a palm surface coupled to a housing of said computer and located to the side of said touch input device.

29. A haptic feedback touch control as recited in claim 18 wherein sound electronics of said computer are used to drive said at least one actuator.

30. An actuator providing a linear force output, the actuator comprising:

a grounded ferromagnetic piece including a center pole located between two side poles;

a coil wrapped around said center pole;

a magnet positioned adjacent to said center pole and said side poles, wherein an air gap is provided between said magnet and said ferromagnetic piece; and

a backing plate coupled to said magnet, wherein said backing plate and said magnet move with respect to said grounded ferromagnetic piece when current is flowed in said coil.

31. An actuator as recited in claim 30 further comprising rollers positioned between said ferromagnetic piece and said backing plate to allow said relative motion between said backing plate and said ferromagnetic piece.

32. An actuator as recited in claim 31 wherein said rollers are constrained by a cage member.

33. An actuator as recited in claim 30 further comprising a flexure coupled between said backing plate and said ferromagnetic piece, said flexure reducing relative motion between said backing plate and said ferromagnetic piece in undesired directions and providing a spring centering force between said backing plate and said ferromagnetic piece.

34. An actuator as recited in claim 30 wherein an entire thickness of said actuator is approximately 4 millimeters or less.

35. A haptic touch device comprising:

a piezoelectric transducer coupled to a ground, said piezoelectric transducer including a metal diaphragm coupled to a ceramic element;

a planar sensing element operative to sense a location of a contact from a user on a surface of said planar sensing element and provide information representing said location to a computer controller;

a spacer provided between said piezoelectric transducer and said planar sensing element, wherein said metal diaphragm contacts said spacer; and

a spring element coupled between said planar sensing element and said ground, said spring element providing a spring restoring force to said planar sensing element.

36. A haptic touch device as recited in claim 35 wherein said piezoelectric transducer is driven with a signal approximately at a natural frequency of said haptic touch device.

37. A haptic touch device as recited in claim 35 wherein said natural frequency can be adjusted by adjusting a spring constant of said spring element or adjusting a mass of said spacer or said planar sensing element.

38. A method for providing haptic feedback to a touch input device that provides input to a computer device, said computer device implementing a graphical environment, the method comprising:

receiving a position signal from said touch input device, said position signal indicating a contact location on a surface of said touch input device where said user is pressing said surface;

determining in which of a plurality of regions said contact location is positioned, wherein said surface of said touch input device is divided into said plurality of regions; and

providing force information to cause at least one actuator to output a force to said user operating said touch input device, said force associated with said user moving an object on or over said surface of said touch input device.

39. A method as recited in claim 38 further comprising implementing a function associated with said region in which said contact location is positioned.

40. A method as recited in claim 39 wherein said function associated with said region includes a rate control function of a value.

41. A method as recited in claim 39 wherein said function associated with said region includes moving a displayed cursor to a screen position based on said position signal.

42. A method as recited in claim 39 wherein said function associated with said region includes a function that can also be initiated by selecting a graphical button displayed by an application program running on said computer device.

43. A method as recited in claim 38 wherein said force is output when said user moves said object over a boundary to said region in which said contact location is positioned from a different region of said touch input device.

44. A method as recited in claim 38 wherein said object moved on or over said surface of said touch input device includes a finger of said user or an object held by said user.

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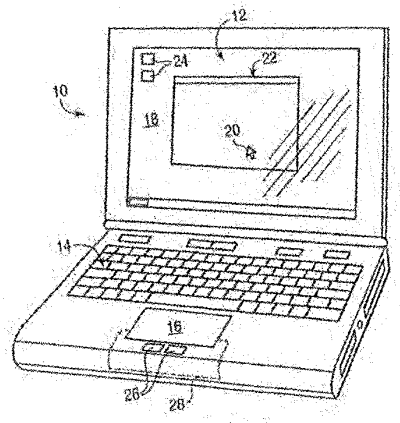


FIG. 1

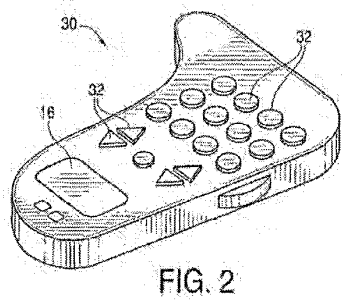


FIG. 2

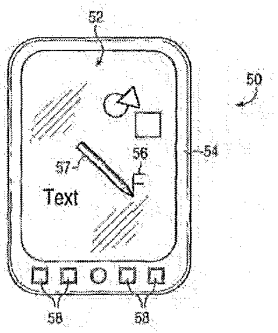


FIG. 3

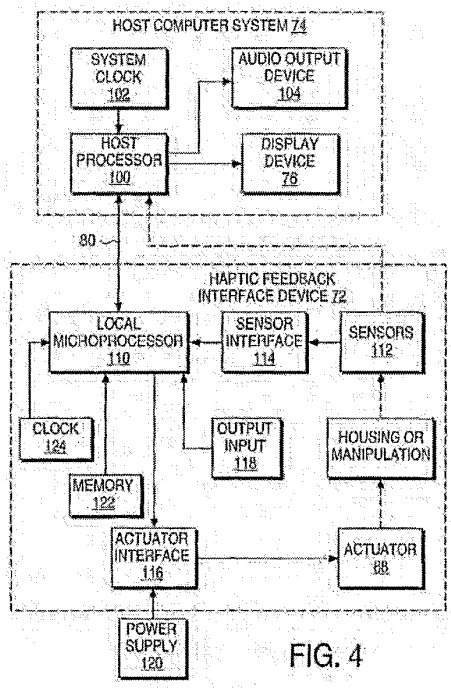

HOST COMPUTER SYSTEM 74
SYSTEM CLOCK 102
AUDIO OUTPUT DEVICE 104
HOST PROCESSOR 100
DISPLAY DEVICE 76
80
HAPTIC FEEDBACK INTERFACE DEVICE 72
LOCAL MICROPROCESSOR 110
SENSOR INTERFACE 114
SENSORS 112
CLOCK 124
OUTPUT INPUT 118
HOUSING OR MANIPULATION
MEMORY 122
ACTUATOR INTERFACE 116
ACTUATOR 88
POWER SUPPLY 120

FIG. 4

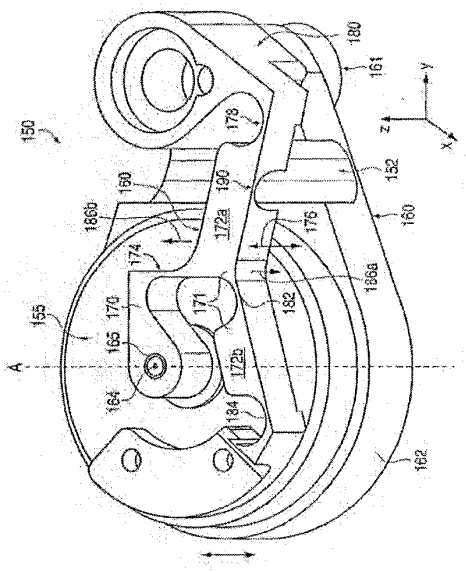

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FIG. 5

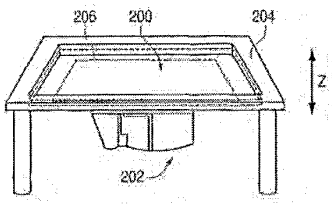


FIG. 6

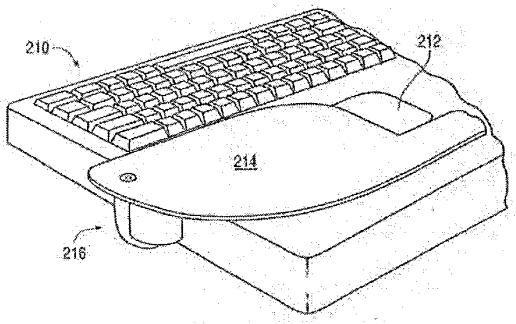


FIG. 7

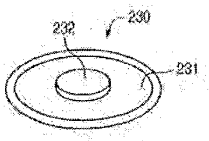

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FIG. 8A

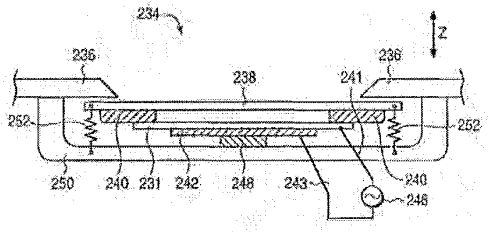

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FIG. 8B

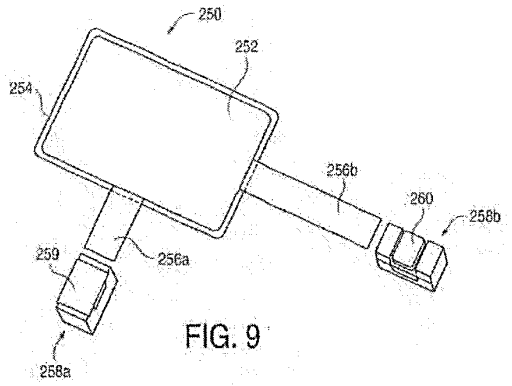

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FIG. 9

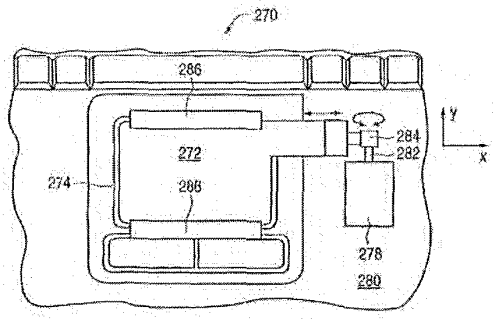

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FIG. 10

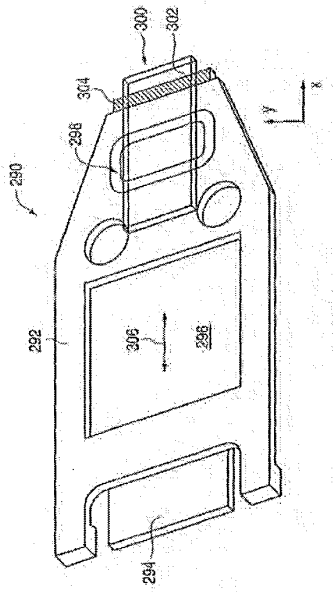


FIG 11

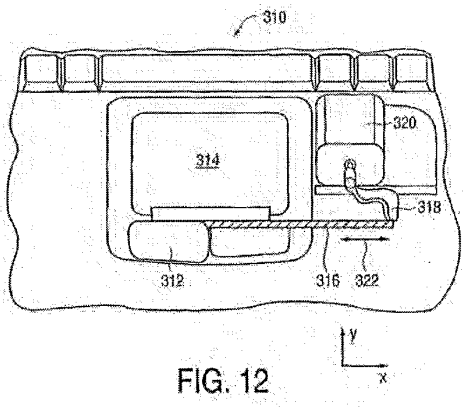


FIG. 12

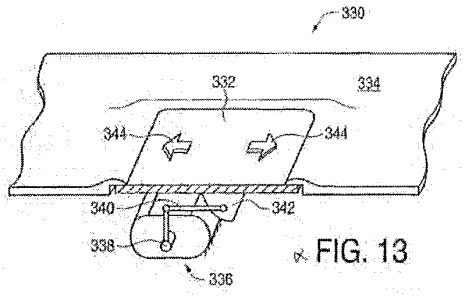

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FIG. 13

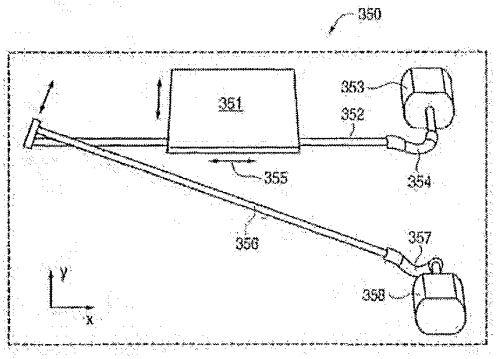
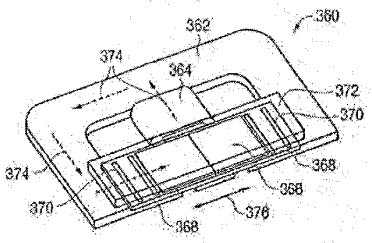

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FIG. 14

FIG. 15A



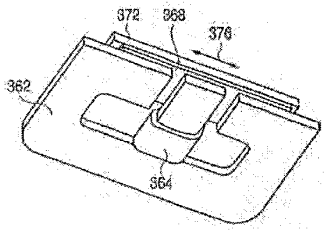


FIG. 15B

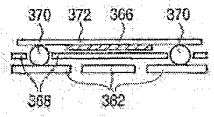


FIG. 15C

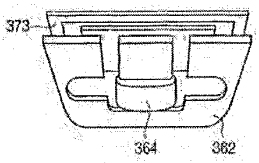


FIG. 15D

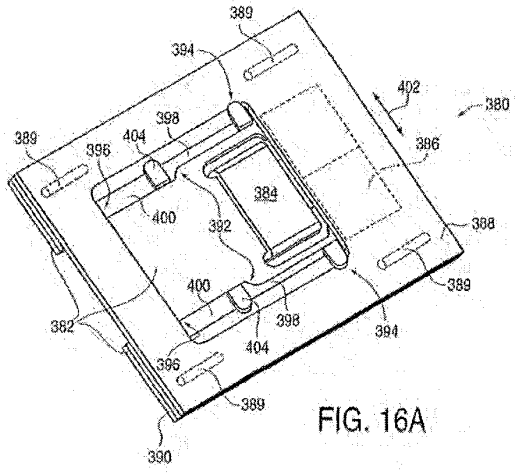

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FIG. 16A

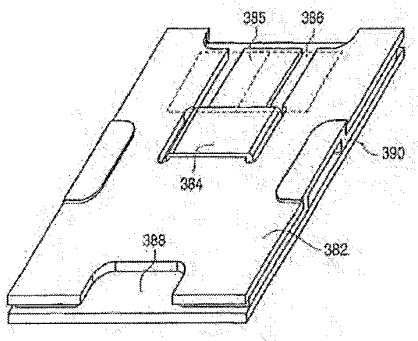


FIG. 16B

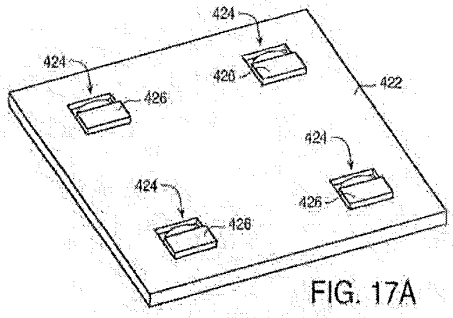


FIG. 17A

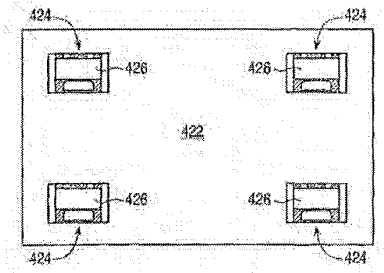


FIG. 17B

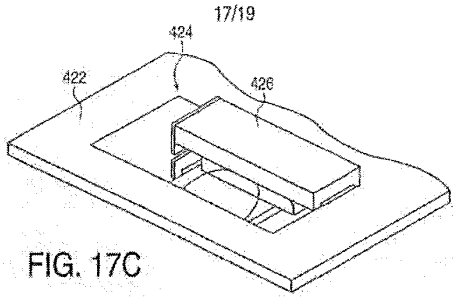


FIG. 17C

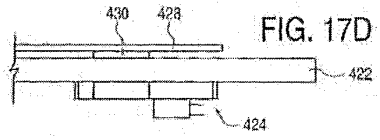


FIG. 17D

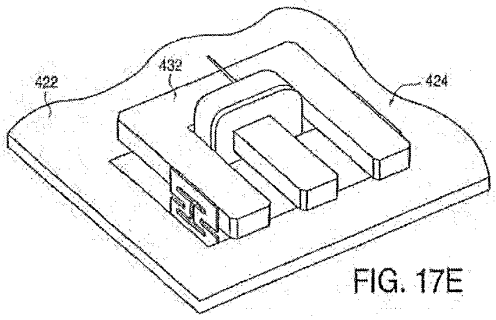
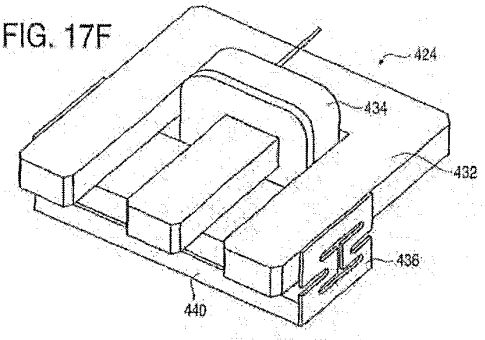


FIG. 17E

FIG. 17F



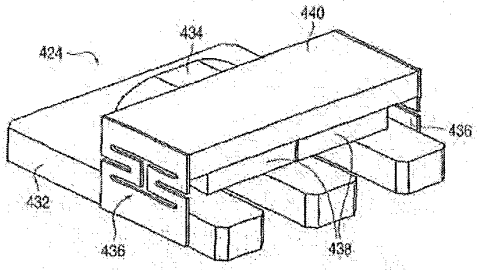


FIG. 17G

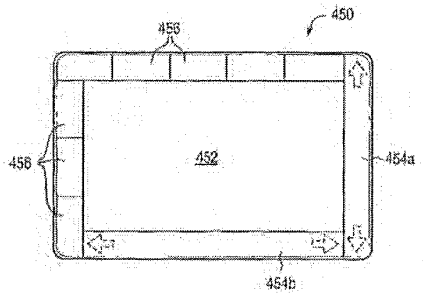


FIG. 18

【国際調査報告】

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/07107

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G09G 3/00
US CL : 345/156, 157, 161, 169
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 345/156, 157, 161, 169

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WEST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,998,903 A (HOLEHAN) 23 November 1999 (23.11.1999), see abstract.	1-44
A	US 5,887,995 A (HOLEHAN) 30 March 1999 (30.03.1999), see abstract	1-44
A	US 4,892,756 A (CLARK) 09 September 1987 (09.09.1987), see column 3, lines 22-66.	1-44

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 May 2002 (09.05.2002)	13 JUN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Ronald Laneau Telephone No. (703) 305-9717

Form PCT/ISA/210 (second sheet) (July 1998)

フロントページの続き

(81)指定国 AP(GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZM,ZW),EA(AM,AZ,BY,KG,KZ,MD,RU,TJ,TM),EP(AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE,TR),OA(BF,BJ,CF,CG,CI,CM,GA,GN,GQ,GW,ML,MR,NE,SN,TD,TG),AE,AG,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CO,CR,CU,CZ,DE,DK,DM,DZ,EC,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,MZ,NO,NZ,OM,PH,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TN,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZM,ZW

(特許庁注：以下のものは登録商標)
ＵＮＩＸ

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Ｆターム(参考) 5B087 AA09 AB12 BC13 BC19 BC26 DD03 DE07

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Michael D. Levin	)	
	)	Conf. No.: 2809
Serial No. 11/965,046	)	
	)	Art Unit: 2623
Filed: December 27, 2007	)	
	)	Examiner: Zubajlo, Jennifer L.
For: **VIRTUAL DETENTS THROUGH VIBROTACTILE FEEDBACK**	)	
	)	
	)	
	)	
	)	
Attorney Ref. IMM253 (051851-0339922)	)	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to 37 C.F.R. §§ 1.97 and 1.98, applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I.. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the PTO/SB/08 forms attached hereto.

II. COPIES (check at least one box)

a. ☐ This application was filed before June 30, 2003. Accordingly, submitted herewith is a legible copy of (i) each U.S. and foreign patent; (ii) each publication or that portion which caused it to be listed; and (iii) all other information or that portion which caused it to be listed.

b. ☒ This application was filed on or after June 30, 2003. Accordingly, copies of cited U.S. patents and patent application publications therefore are not included. Copies of foreign patent documents and non-patent literature are included.

c. ☐ Some or all of the documents listed on the PTO/SB/08 forms are not enclosed because they were cited in the International Search Report and copies should already be in the PTO file. If copies are needed, please contact the undersigned.

III. CONCISE EXPLANATION OF THE RELEVANCE
(check at least one box)

a. ☐ **DOCUMENTS IN THE ENGLISH LANGUAGE**
The patents, publications, or other information listed on the attached PTO/SB/08 forms are in the English language and therefore, do not require a statement of relevancy.

b. ☒ **DOCUMENTS NOT IN THE ENGLISH LANGUAGE**
A concise explanation of the relevance of all patents, publications, or other information listed that is not in the English language is as follows:

JP 2004-530200 has an English Language Abstract.
Japanese Patent Office, Decision of Rejection, Application No. 2015-087121 dated August 8, 2016, for which no English language version is available.

c. ☐ **ENGLISH LANGUAGE SEARCH REPORT**
An English language version of the search report or action that indicates the degree of relevance found by the foreign office is attached, thereby satisfying the requirement for a concise explanation. See MPEP 609(III)(A)(3).

d. ☐ **OTHER**
The following additional information is provided for the Examiner's consideration.

FEES

IV. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(b):
(check one box)

a. ☐ within three months of the filing date of a national application (37 C.F.R. § 1.97(b)(1)). No fee or statement is required. *(This section is not to be used with RCE's.)*

b. ☐ within three months of the date of entry of the national stage as set forth in § 1.491 in an international application (37 C.F.R. § 1.97(b)(2)). No fee or statement is required.

c. ☐ before the mailing of a first Office action after the filing of or concurrently with a Request for Continued Examination under § 1.114 (37 C.F.R. § 1.97(b)(4)). No fee or statement is required.

d. ☐ before the mailing date of a first Action on the merits (37 C.F.R. § 1.97(b)(3)). No fee or statement is required.

In the event that a first Office Action on the merits has been issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) below, or, if no statement has been made, charge our deposit account in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

V. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(c):
(check one box)

before the mailing date of a Final Office Action under 37 C.F.R. § 1.113 (See 37 C.F.R. § 1.97(c)(1)) or before the mailing date of a Notice of Allowance under 37 C.F.R. § 1.311 (See 37 C.F.R. § 1.97(c)(2)).

a. ☐ No statement; therefore, a fee in the amount of $180.00 as required by 37 C.F.R. § 1.17(p).

b. ☐ See the statement below. No fee is required.

VI. ☐ THIS IDS IS BEING FILED UNDER 37 C.F.R. § 1.97(d)
after the period specified in 37 C.F.R. 1.97(c) but before payment of the issue fee; see statement and payment of fees below.

VII. STATEMENT UNDER 37 C.F.R. § 1.97(e) (check only one box)
The undersigned hereby states that

a. ☒ each item of information contained in the IDS was first cited in any communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS;

b. ☐ no item of information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS.

c. ☐ Some of the items of information were cited in a communication from a foreign Patent Office. As to this information, the undersigned states that each item of information contained in the IDS was first cited in a communication from a foreign Patent Office in a counterpart foreign application not more than three months prior to the filing of this IDS. As to the remaining information, the undersigned hereby states that no item of this remaining information contained in the IDS was cited in a communication from a foreign Patent Office in a counterpart foreign application and, to the best of my knowledge after making reasonable inquiry, was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

VIII. ☒ PATENT TERM ADJUSTMENT

Each item of information contained in this Information Disclosure Statement was first cited in a communication from a foreign patent office in a counterpart application and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of this Information Disclosure Statement. 37 C.F.R. § 1.704(d).

IX. PAYMENT OF FEES (check one box)

☐ Payment by credit card Form PTO-2038 in the amount of $180 required by 37 C.F.R. § 1.17(p) is enclosed for the above-identified fee.

☐ Please charge Deposit Account No. 20-1430 in the amount required by 37 C.F.R. § 1.17(p) for the above-indicated fee. A triplicate copy of this paper is attached.

☒ Payment made via EFS-Web.

☐ No fee is required.

If the Examiner has any questions concerning this IDS, he/she is requested to contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the PTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 20-1430.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 20-1430 for any additional fees required under 37 C.F.R. § 1.16 or under § 1.17.

Respectfully submitted,

Date: 8/23/2016

By: /Michael Morlock/

Michael T. Morlock (Reg. No. 62,245)

Attachment(s):
☒ PTO/SB/08
☒ Documents
☒ Fee
☐ Other

Electronic Patent Application Fee Transmittal

Application Number:	11965046
Filing Date:	27-Dec-2007
Title of Invention:	Virtual Detents Through Vibrotactile Feedback
First Named Inventor/Applicant Name:	Michael D. Levin
Filer:	Michael T. Morlock/Amber Johnson
Attorney Docket Number:	IMM253

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	26730932
Application Number:	11965046
International Application Number:	
Confirmation Number:	2809
Title of Invention:	Virtual Detents Through Vibrotactile Feedback
First Named Inventor/Applicant Name:	Michael D. Levin
Customer Number:	34300
Filer:	Michael T. Morlock/Amber Johnson
Filer Authorized By:	Michael T. Morlock
Attorney Docket Number:	IMM253
Receipt Date:	24-AUG-2016
Filing Date:	27-DEC-2007
Time Stamp:	11:50:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$180
RAM confirmation Number	082416INTEFSW11512500
Deposit Account	1003
Authorized User	Jennifer Jacobs
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	Transmittal.pdf	68724 94e14b204699d8b8b8ff9aef392cccf7f82aaecc	no	1
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	08a.pdf	110782 1737007b65069adfa0fd5cf205992bfc919ab9a6	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	JP2004530200.pdf	10691116 d987310de05e50a6081a6f946fc8d62956fc903e	no	196
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
4	Non Patent Literature	Rejection.pdf	98718 551902b72cbed1582b24ee4a128051739c22a3f8	no	2
Warnings:					
Information:					
5	Transmittal Letter	Certification.pdf	104151 af2f584c27bb1e0dcfc1b80839c6e89e42e14e87	no	5
Warnings:					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	30110 744b1f30db0d96bdd05de66a0d33a04c1a573073	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	11103601

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	)	Conf No.: 2809
Michael D. Levin	)	
	)	Art Unit: 2623
Serial No. 11/965,046	)	
	)	Examiner: **Zubajlo, Jennifer L.**
Filed: December 27, 2007	)	
	)	
For: VIRTUAL DETENTS THROUGH VIBROTACTILE FEEDBACK		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Sir:

Transmitted herewith are the following documents for filing in the above-identified application:

1. Supplemental Information Disclosure Statement;
2. Form PTO/SB/08a listing Two (2) Documents;
3. One (1) Foreign Patent Document;
4. One (1) Non-Patent Literature Document; and
5. EFS-Web payment in the amount of $180.

The Commissioner is hereby authorized to charge any deficiency to Deposit Account Number 20-1430.

Respectfully submitted,

Date: 8/23/2016

/Michael Morlock/

Michael T. Morlock
Reg. No. 62,245

KILPATRICK TOWNSEND & STOCKTON LLP
1001 West Fourth Street
Winston-Salem, NC 27101-2400
(336) 607-7300

Certificate of Electronic Filing
I hereby certify that this correspondence is being electronically filed with The United States Patent Office via EFS-Web on August 24, 2016.

/Amber C Johnson/
Amber C. Johnson