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(54) GESTURES FOR TOUCH SENSITIVE INPUT DEVICES

(75) Inventors: **Steve Hotelling**, San Jose, CA (US); **Joshua A. Strickon**, San Jose, CA (US); **Brian Q. Huppi**, San Francisco, CA (US); **Imran Chaudhri**, San Francisco, CA (US); **Greg Christie**, San Jose, CA (US); **Bas Ording**, San Francisco, CA (US); **Duncan Robert Kerr**, San Francisco, CA (US); **Jonathan P. Ive**, San Francisco, CA (US)

Correspondence Address:
BEYER WEAVER & THOMAS LLP
P.O. BOX 70250
OAKLAND, CA 94612-0250 (US)

(73) Assignee: **Apple Computer, Inc.**

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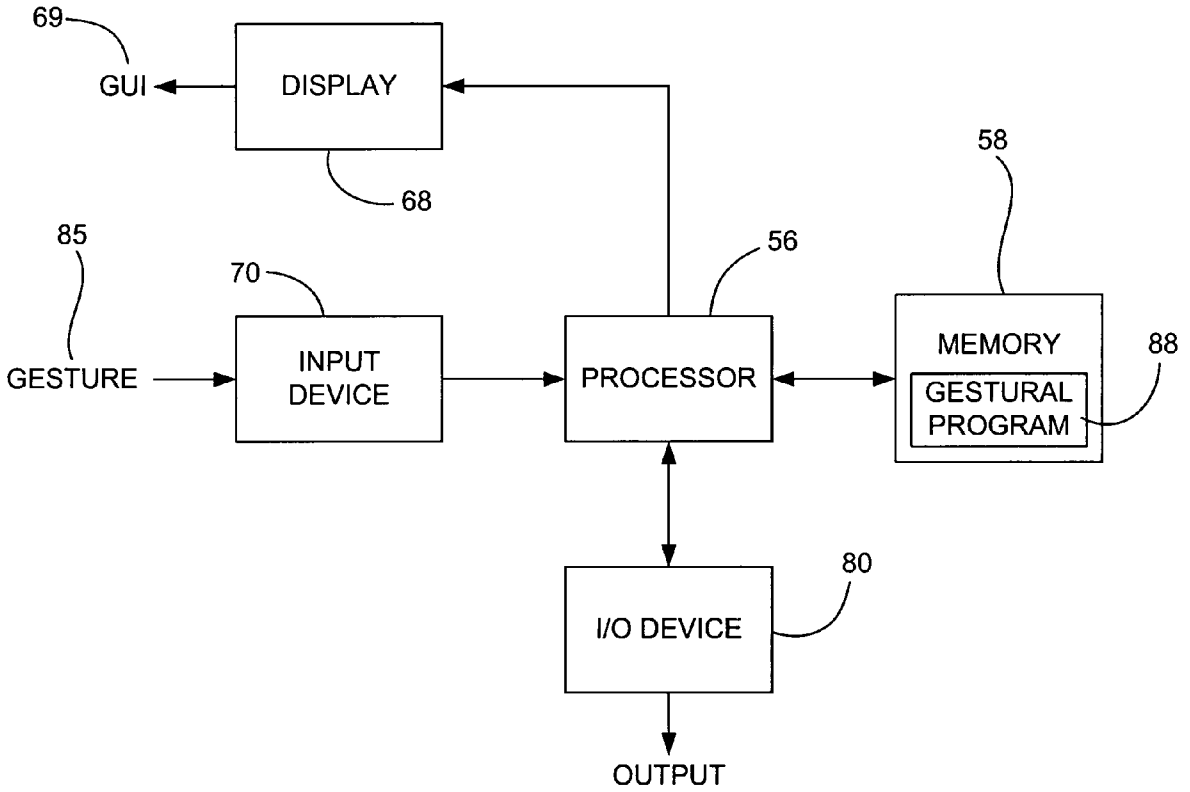
G06F 17/00 (2006.01)

(52) **U.S. Cl.** **715/702**; 715/863

(57) **ABSTRACT**

Methods and systems for processing touch inputs are disclosed. The invention in one respect includes reading data from a multipoint sensing device such as a multipoint touch screen where the data pertains to touch input with respect to the multipoint sensing device, and identifying at least one multipoint gesture based on the data from the multipoint sensing device.



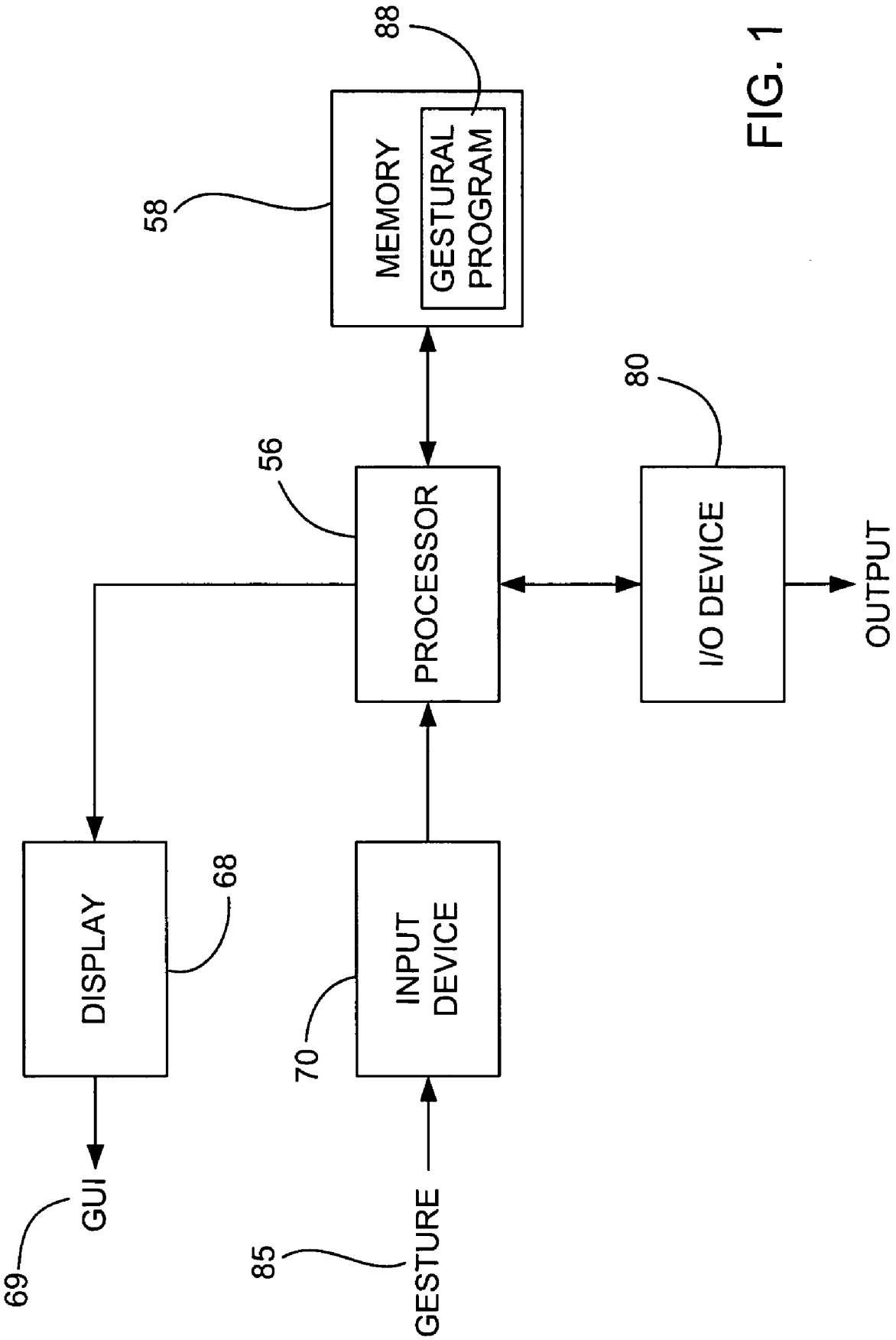

MEMORY
GESTURAL PROGRAM
88
58
PROCESSOR
56
I/O DEVICE
80
OUTPUT
DISPLAY
68
INPUT DEVICE
70
GUI
69
GESTURE
85

FIG. 1

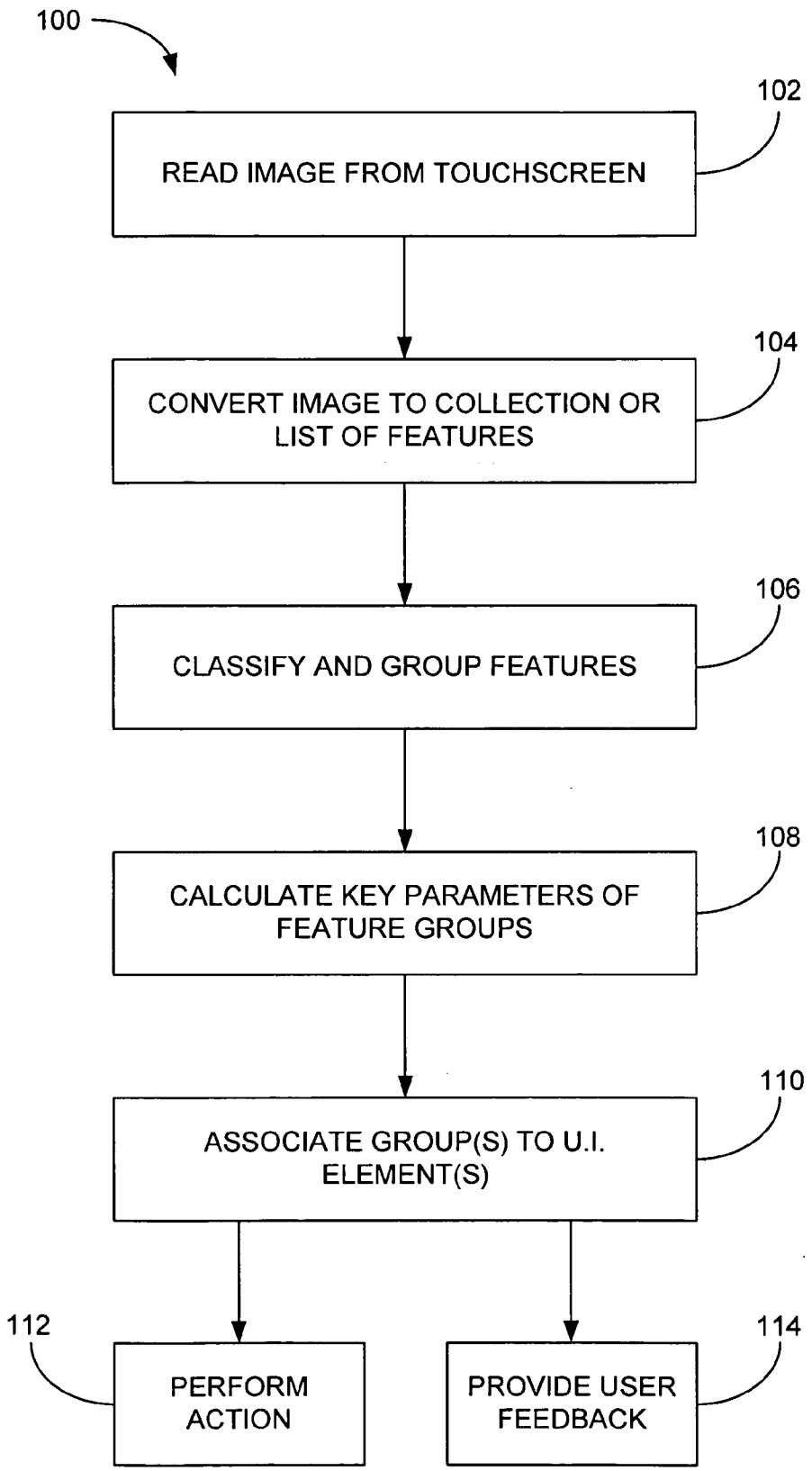

100
102
READ IMAGE FROM TOUCHSCREEN
104
CONVERT IMAGE TO COLLECTION OR LIST OF FEATURES
106
CLASSIFY AND GROUP FEATURES
108
CALCULATE KEY PARAMETERS OF FEATURE GROUPS
110
ASSOCIATE GROUP(S) TO U.I. ELEMENT(S)
112
PERFORM ACTION
114
PROVIDE USER FEEDBACK

FIG. 2

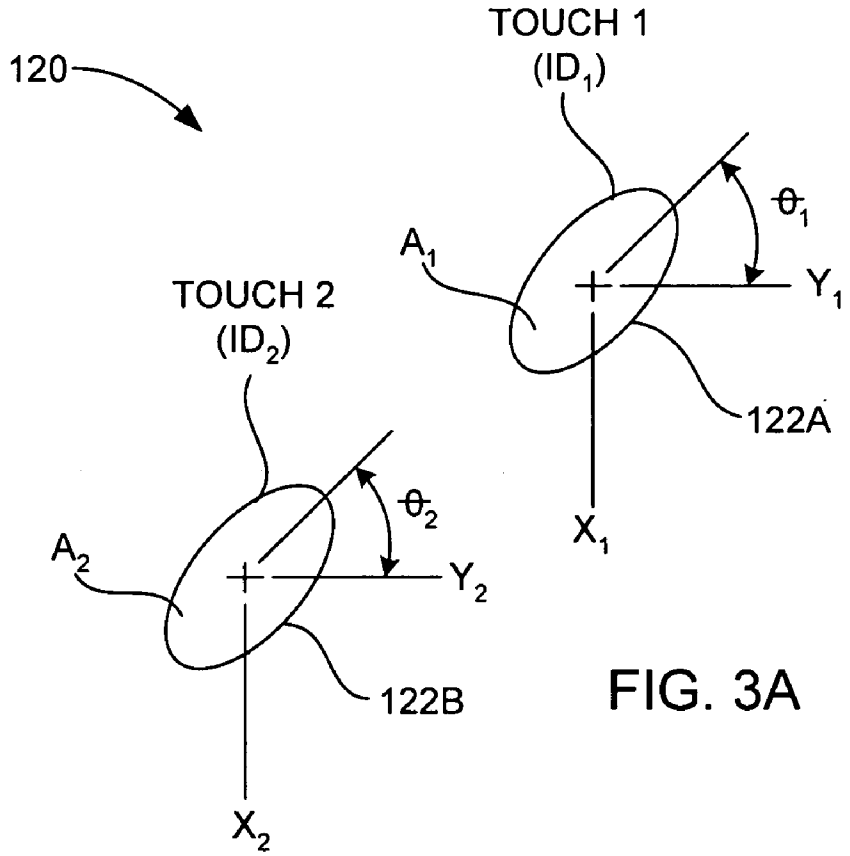

120
TOUCH 1
(ID1)
θ1
A1
Y1
122A
X1
TOUCH 2
(ID2)
θ2
A2
Y2
122B
X2

FIG. 3A

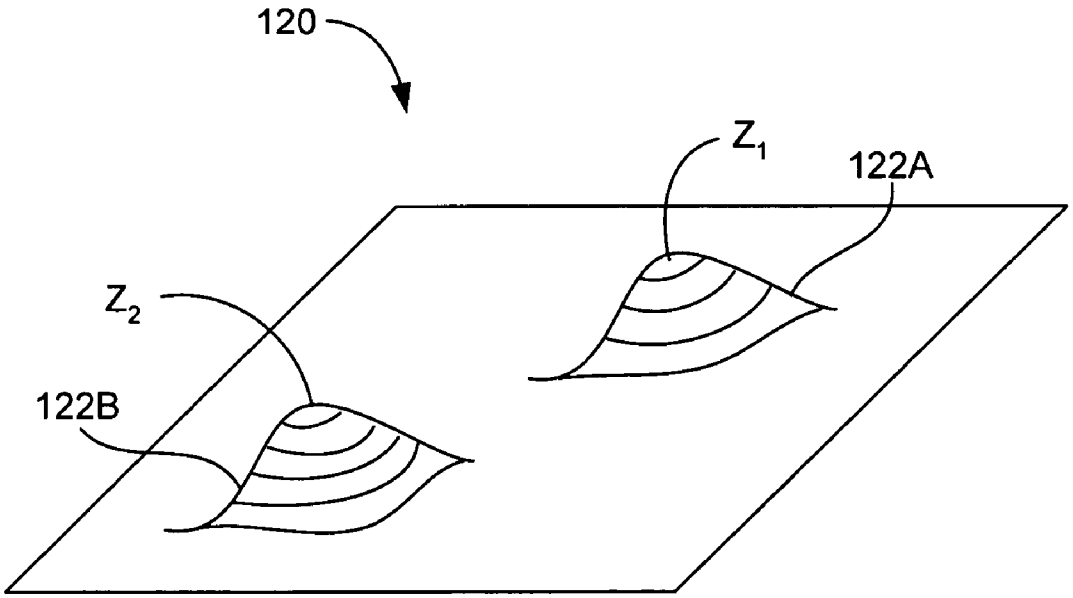

120
Z1
122A
Z2
122B

FIG. 3B

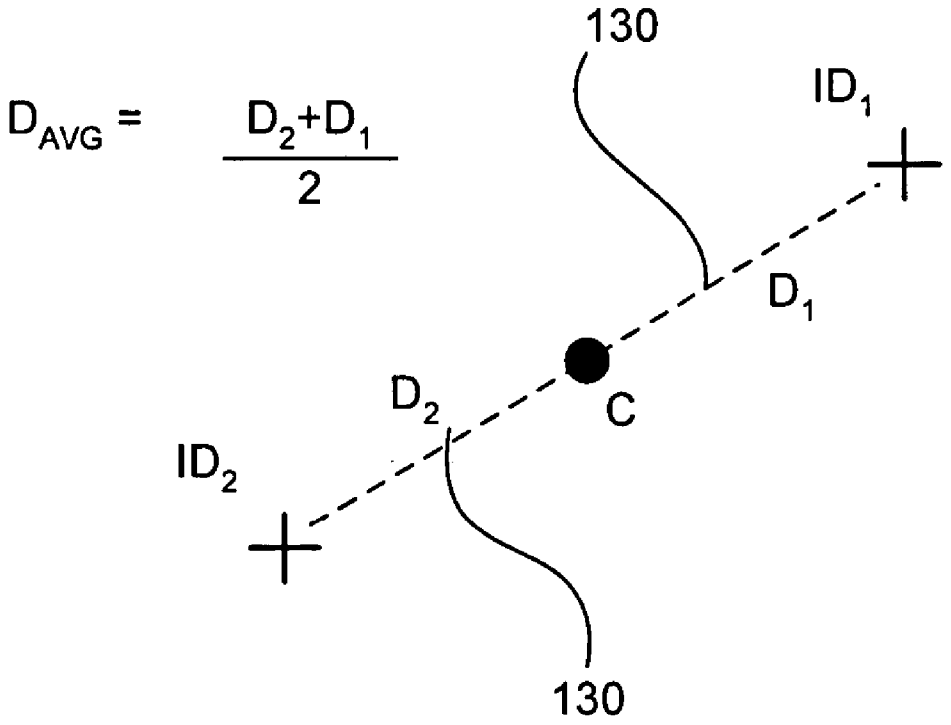


FIG. 4

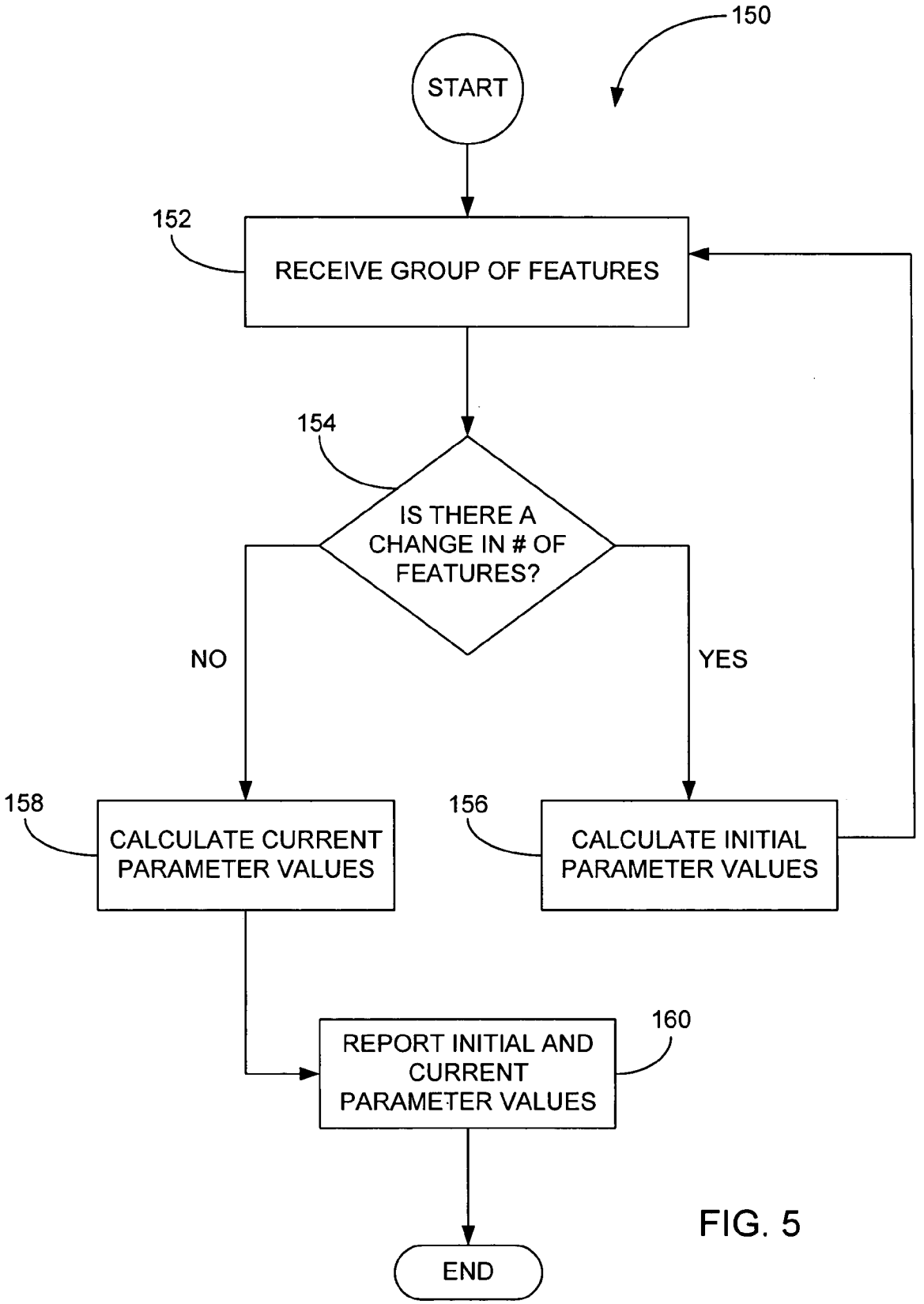

150
START
152
RECEIVE GROUP OF FEATURES
154
IS THERE A CHANGE IN # OF FEATURES?
NO
YES
158
CALCULATE CURRENT PARAMETER VALUES
156
CALCULATE INITIAL PARAMETER VALUES
160
REPORT INITIAL AND CURRENT PARAMETER VALUES
END

FIG. 5

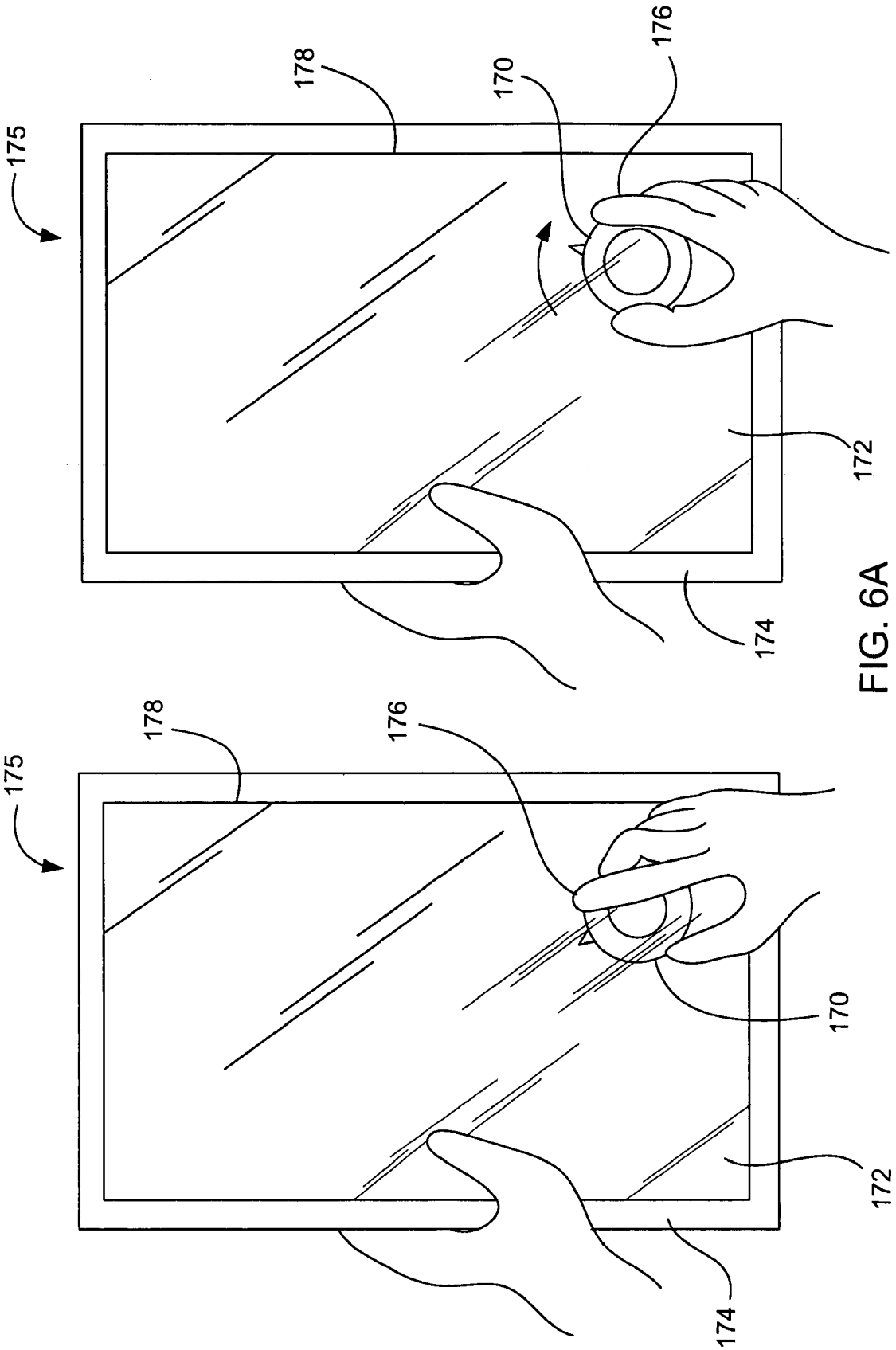


FIG. 6A

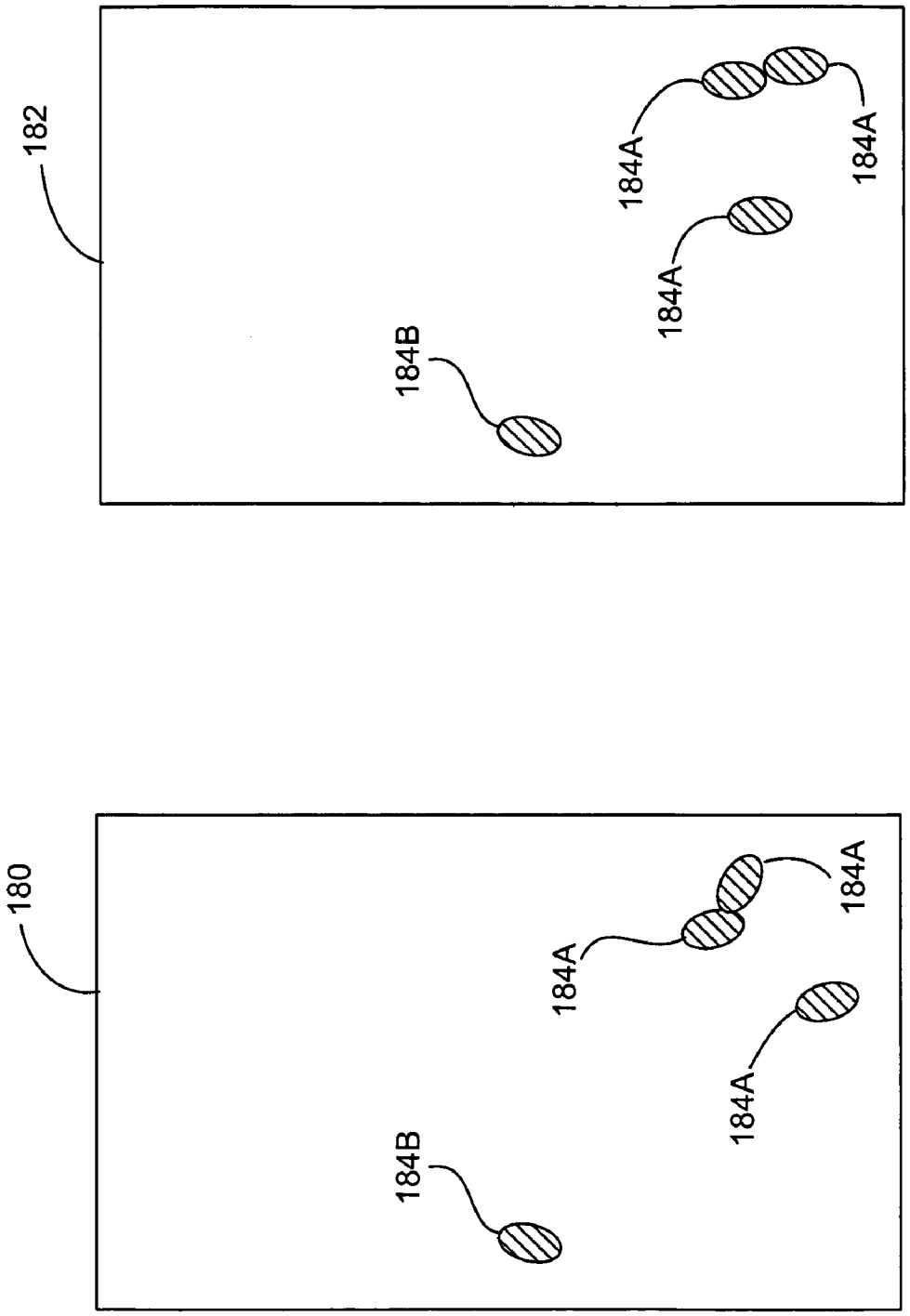
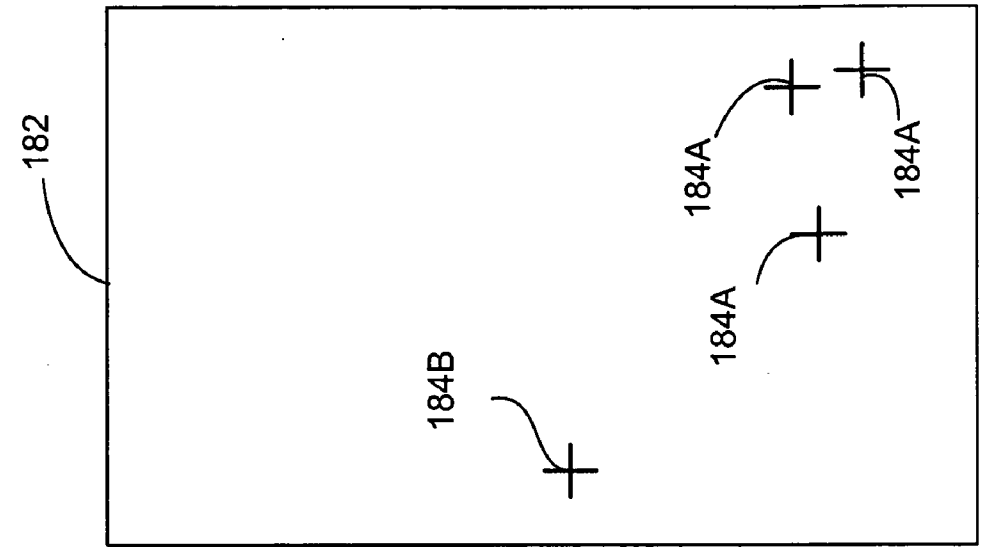


FIG. 6B



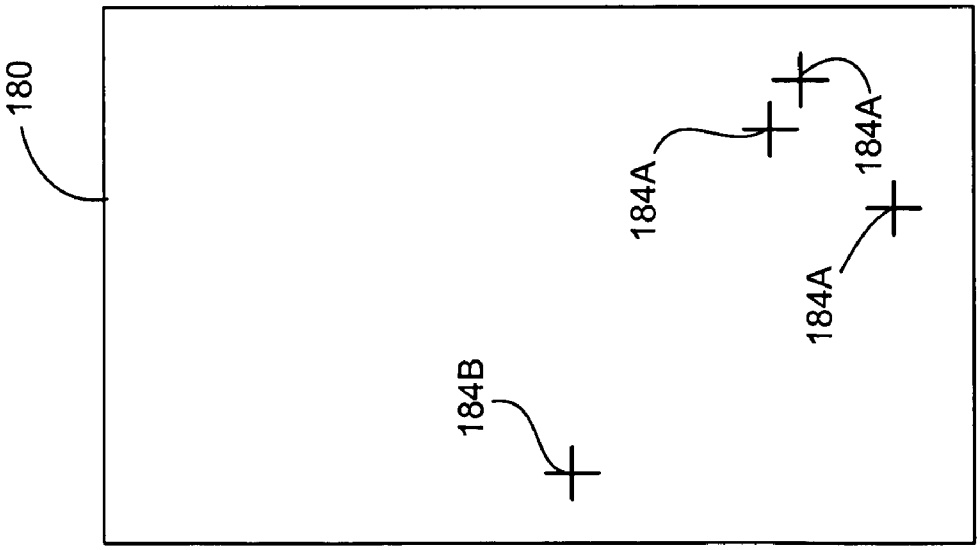


FIG. 6C

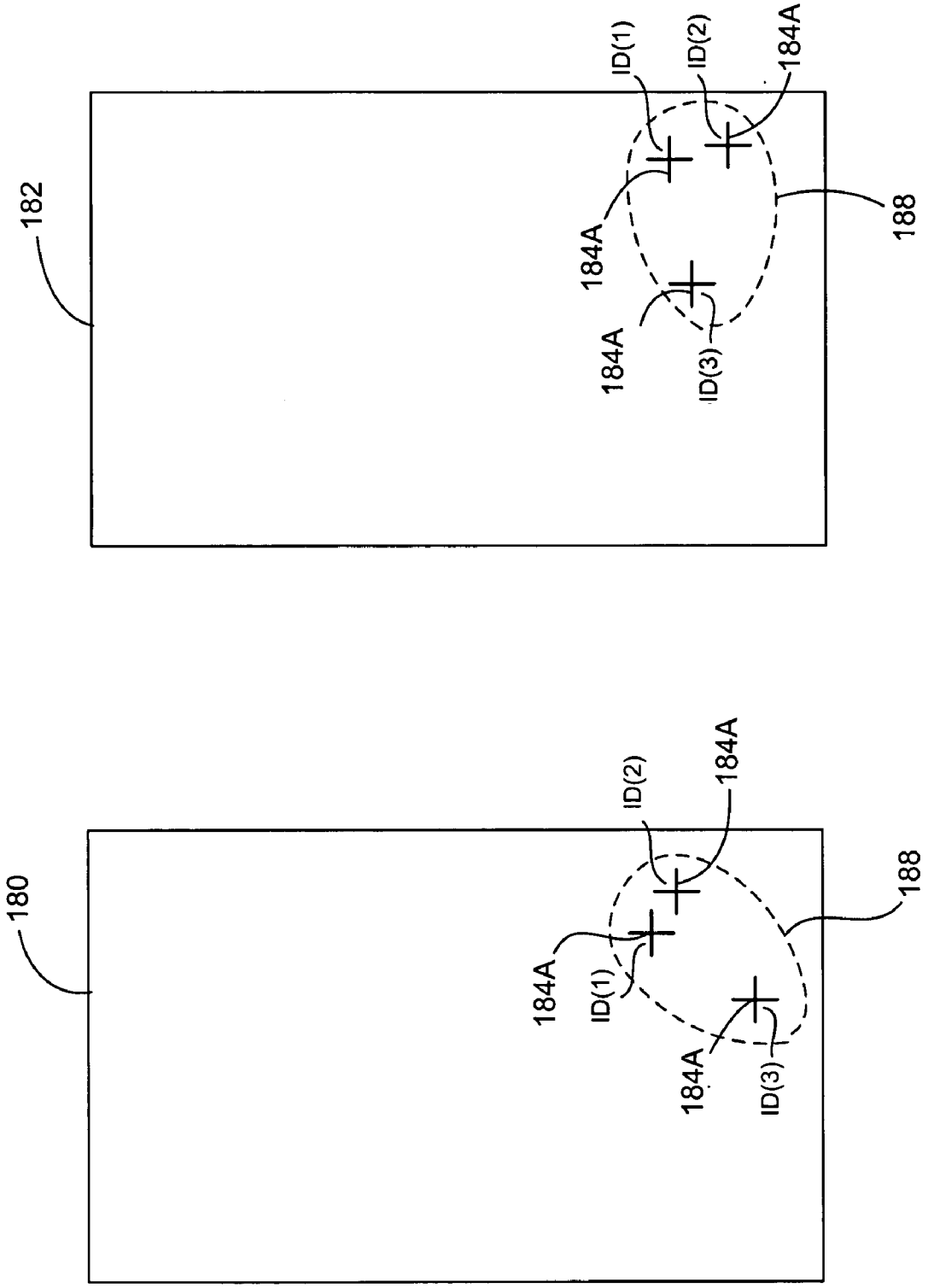

182
184A
ID(1)
ID(2)
184A
184A
ID(3)
188
180
184A
ID(1)
ID(2)
184A
184A
ID(3)
188

FIG. 6D

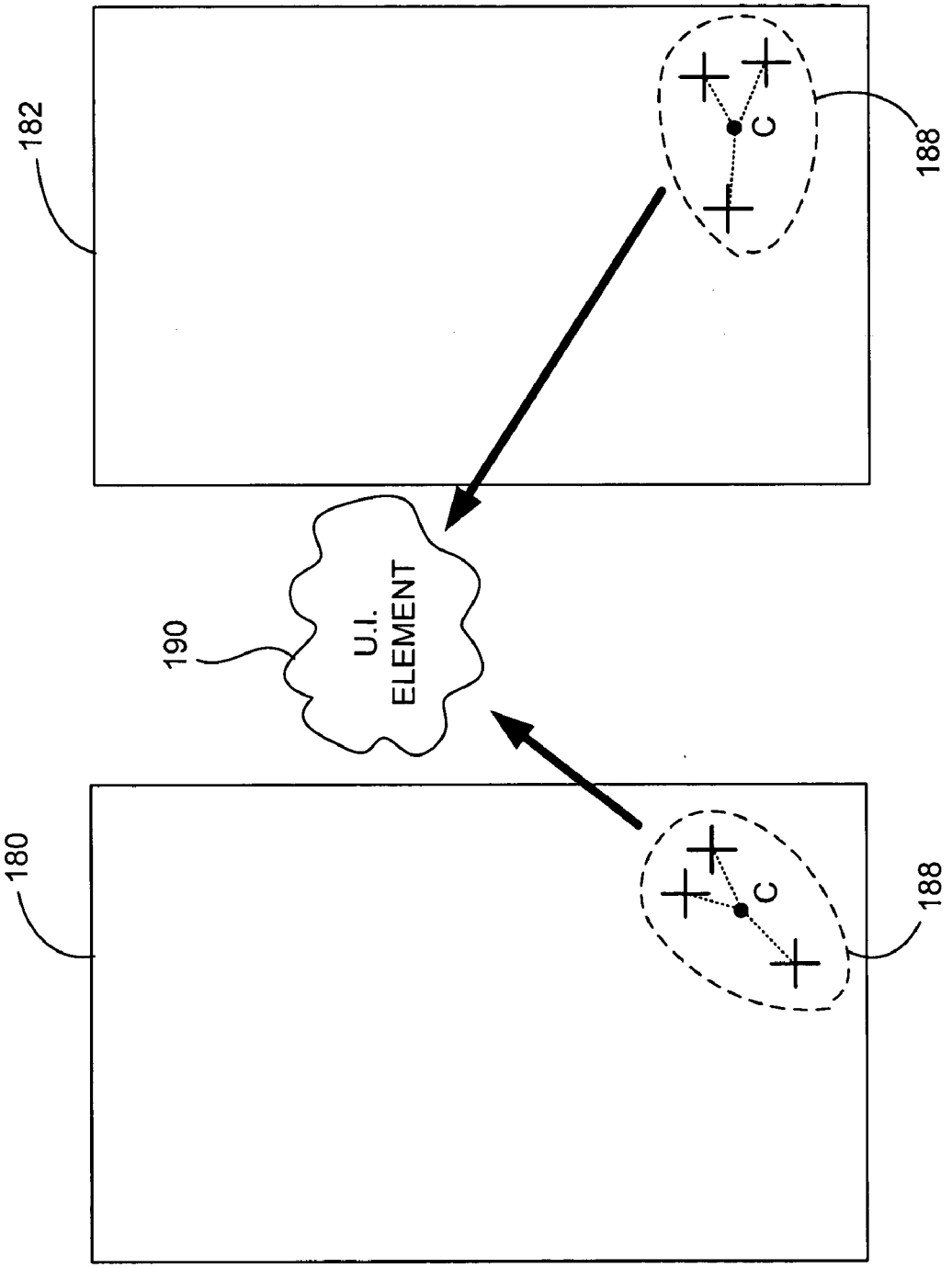


FIG. 6E

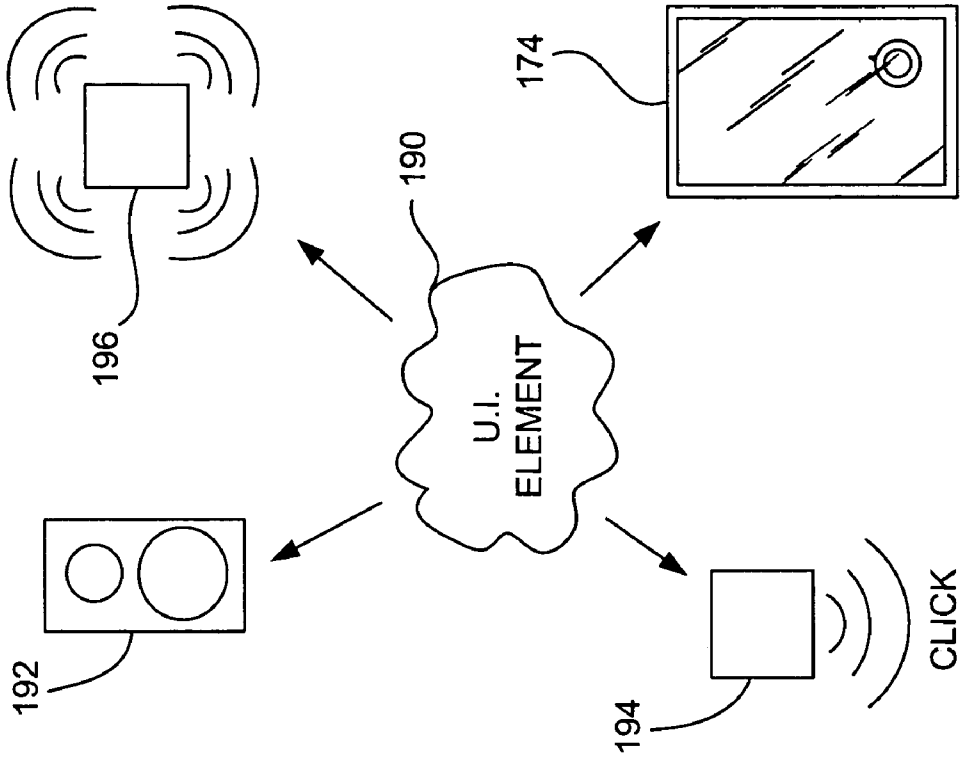


FIG. 6G

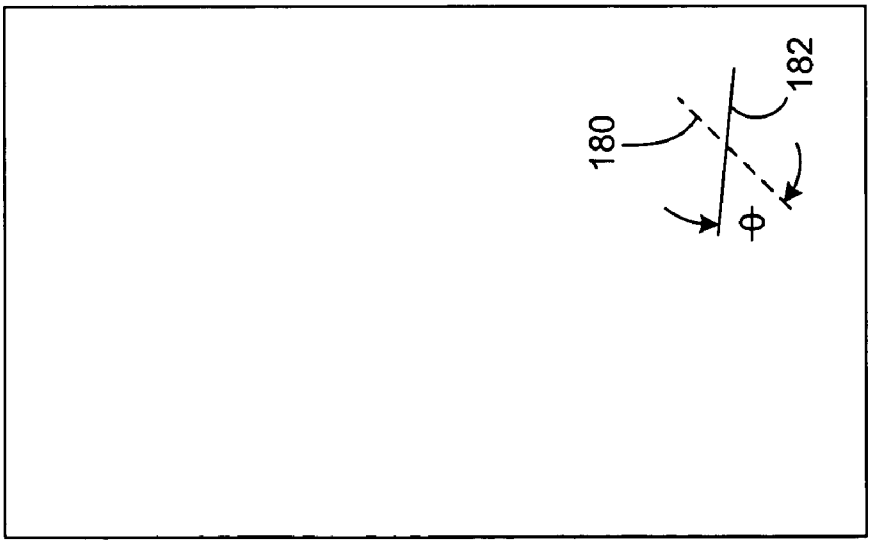


FIG. 6F

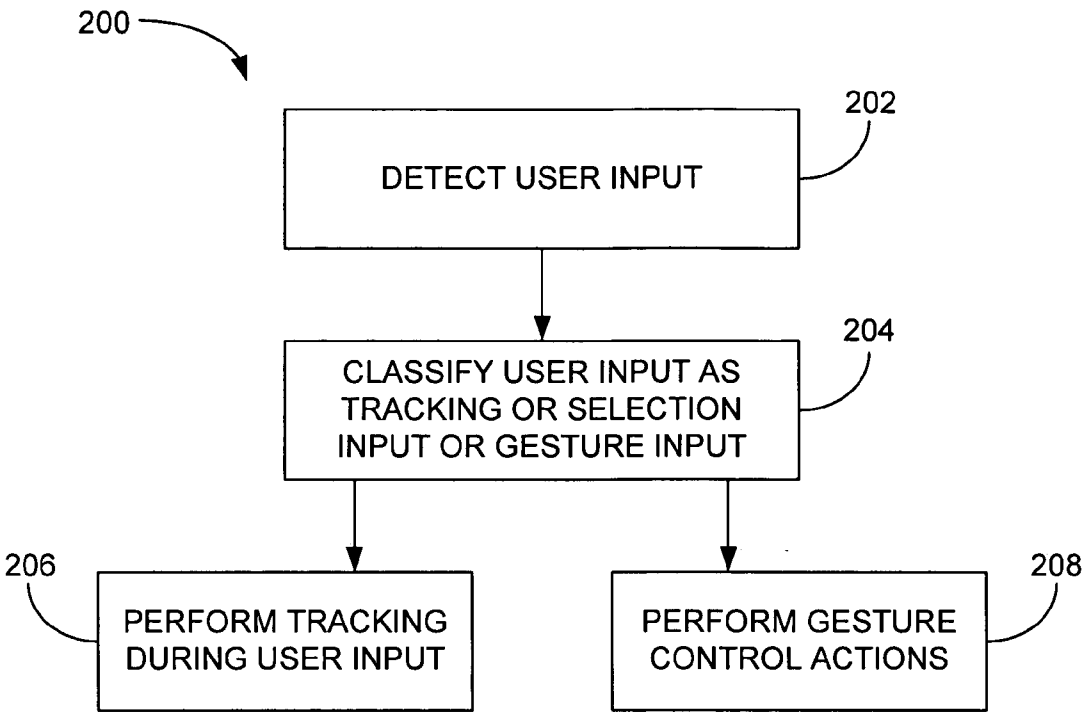

200
DETECT USER INPUT
202
CLASSIFY USER INPUT AS TRACKING OR SELECTION INPUT OR GESTURE INPUT
204
206
PERFORM TRACKING DURING USER INPUT
PERFORM GESTURE CONTROL ACTIONS
208

FIG. 7

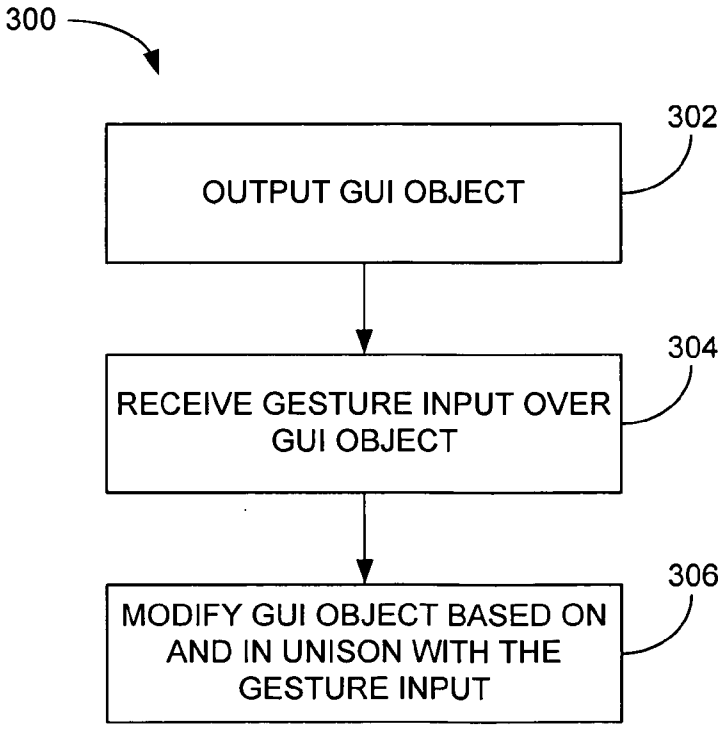

300
OUTPUT GUI OBJECT
302
RECEIVE GESTURE INPUT OVER GUI OBJECT
304
MODIFY GUI OBJECT BASED ON AND IN UNISON WITH THE GESTURE INPUT
306

FIG. 9

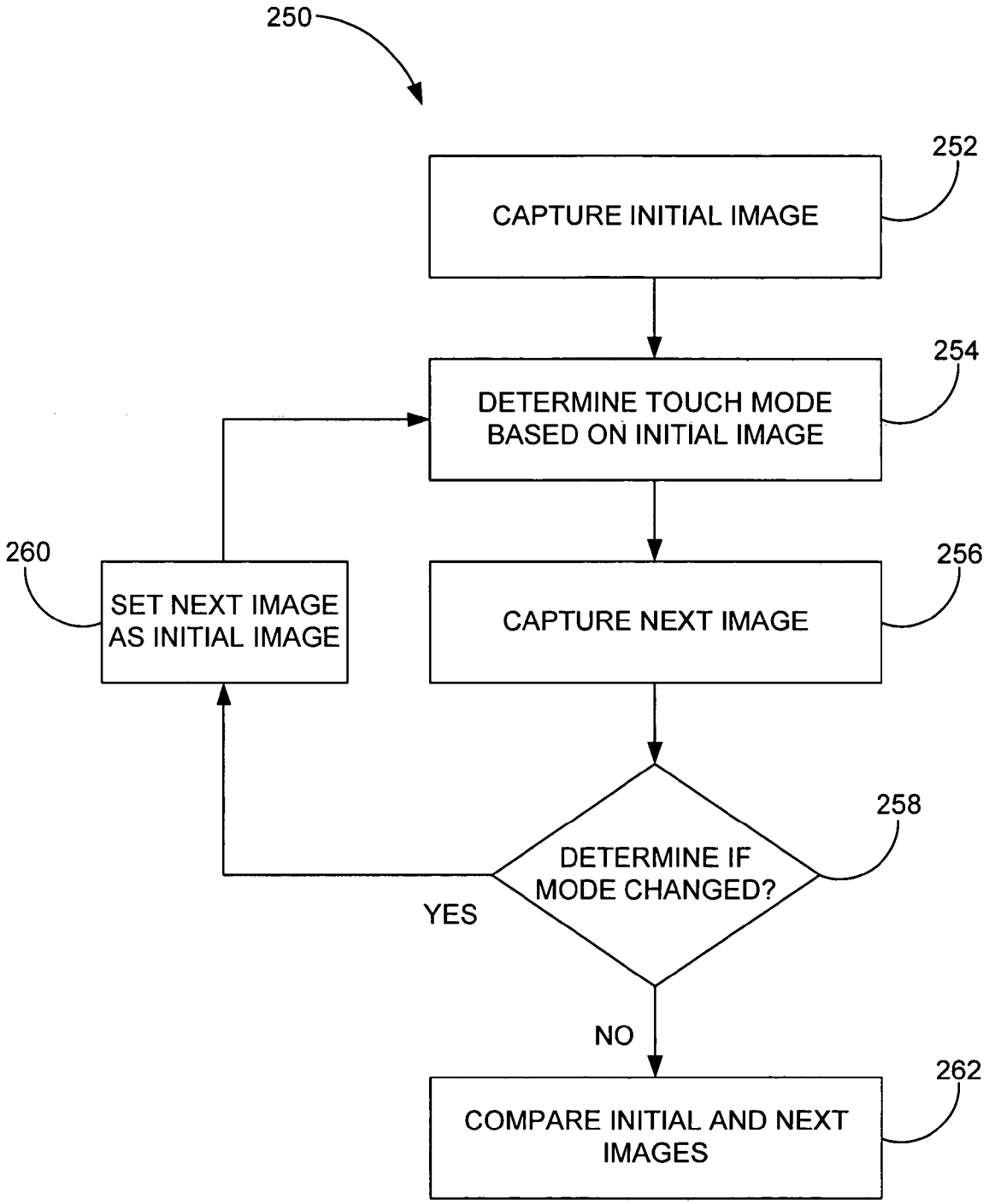

250
CAPTURE INITIAL IMAGE
252
DETERMINE TOUCH MODE BASED ON INITIAL IMAGE
254
CAPTURE NEXT IMAGE
256
DETERMINE IF MODE CHANGED?
258
YES
NO
SET NEXT IMAGE AS INITIAL IMAGE
260
COMPARE INITIAL AND NEXT IMAGES
262

FIG. 8

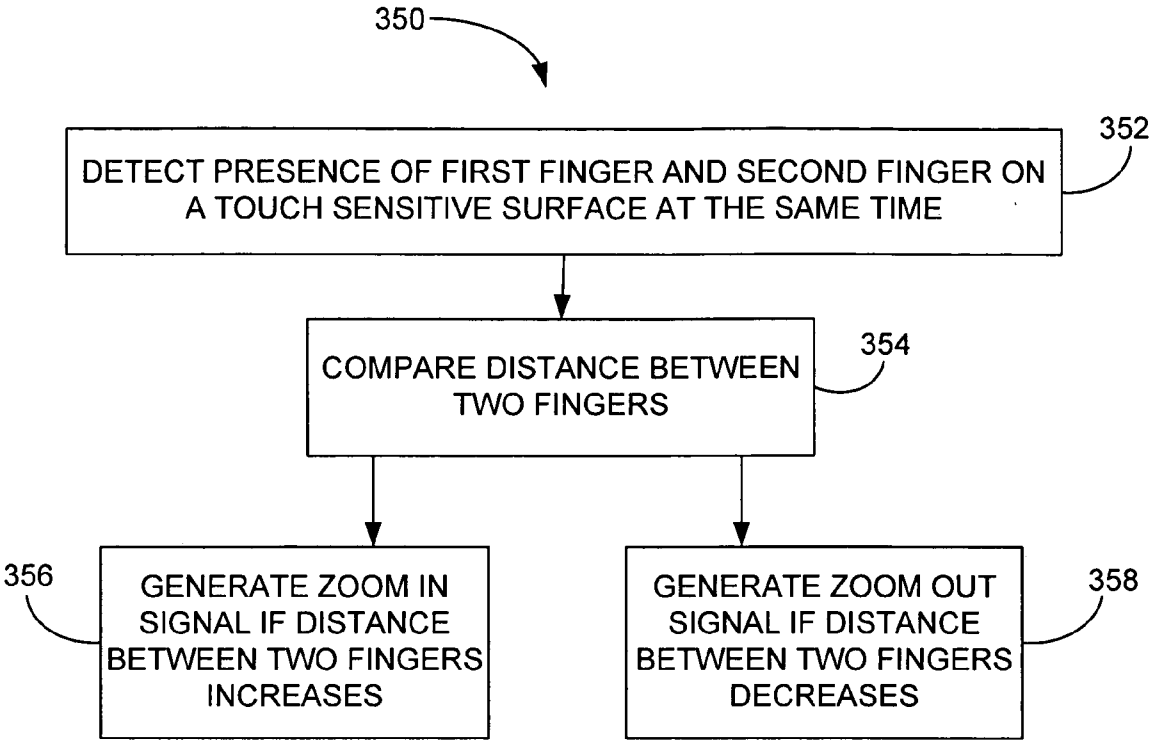

350
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
352
COMPARE DISTANCE BETWEEN TWO FINGERS
354
356
GENERATE ZOOM IN SIGNAL IF DISTANCE BETWEEN TWO FINGERS INCREASES
GENERATE ZOOM OUT SIGNAL IF DISTANCE BETWEEN TWO FINGERS DECREASES
358

FIG. 10

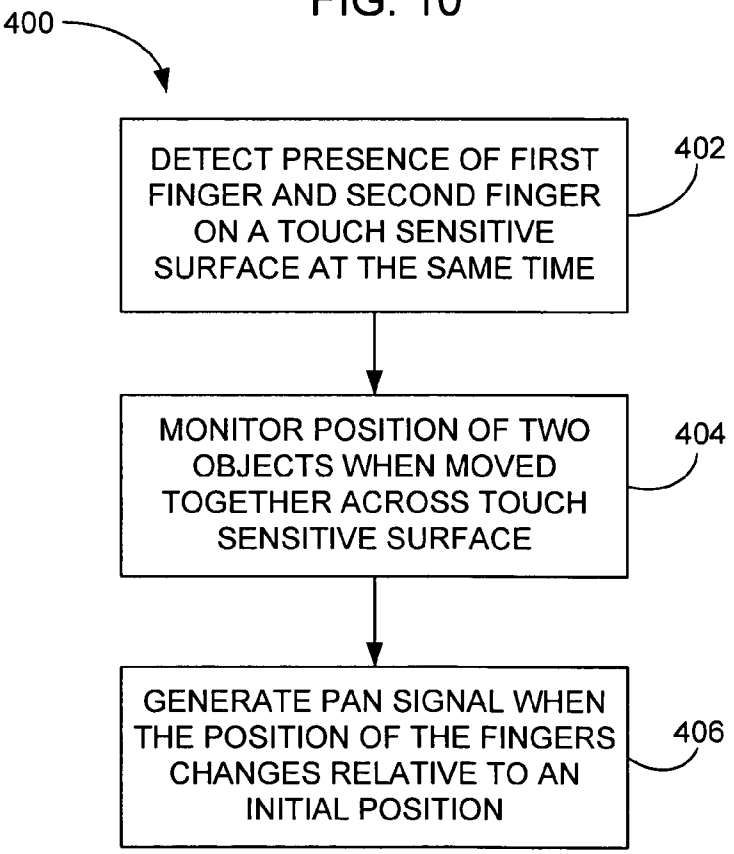

400
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
402
MONITOR POSITION OF TWO OBJECTS WHEN MOVED TOGETHER ACROSS TOUCH SENSITIVE SURFACE
404
GENERATE PAN SIGNAL WHEN THE POSITION OF THE FINGERS CHANGES RELATIVE TO AN INITIAL POSITION
406

FIG. 12

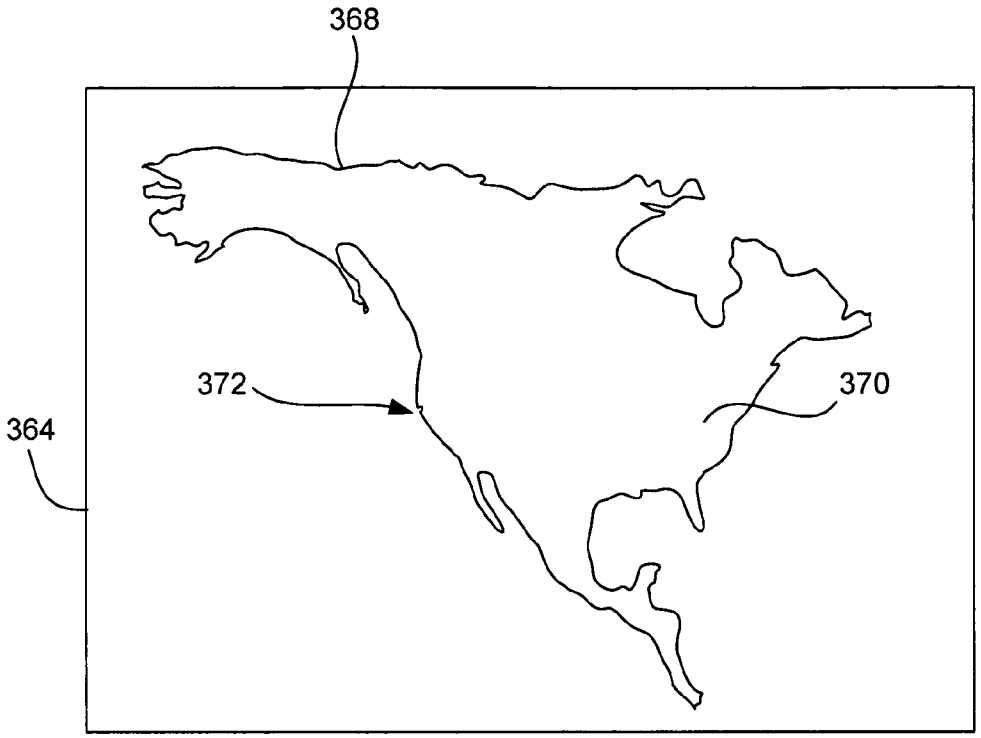


FIG. 11A

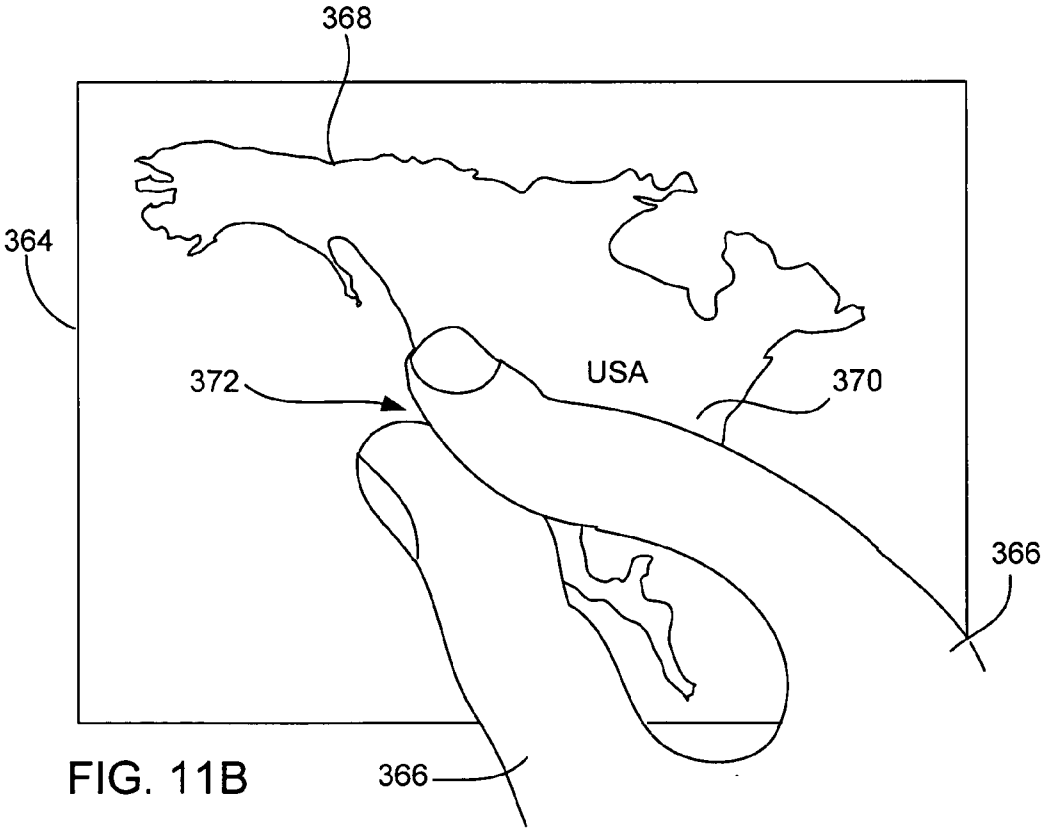


FIG. 11B

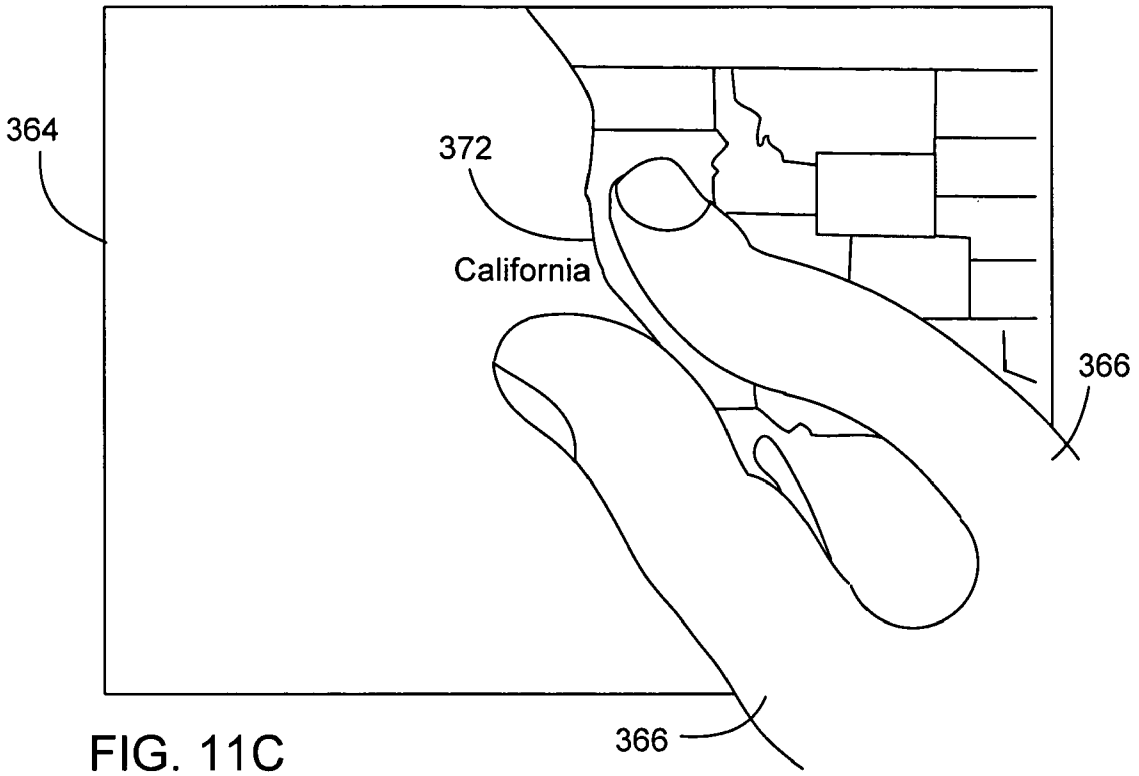


FIG. 11C

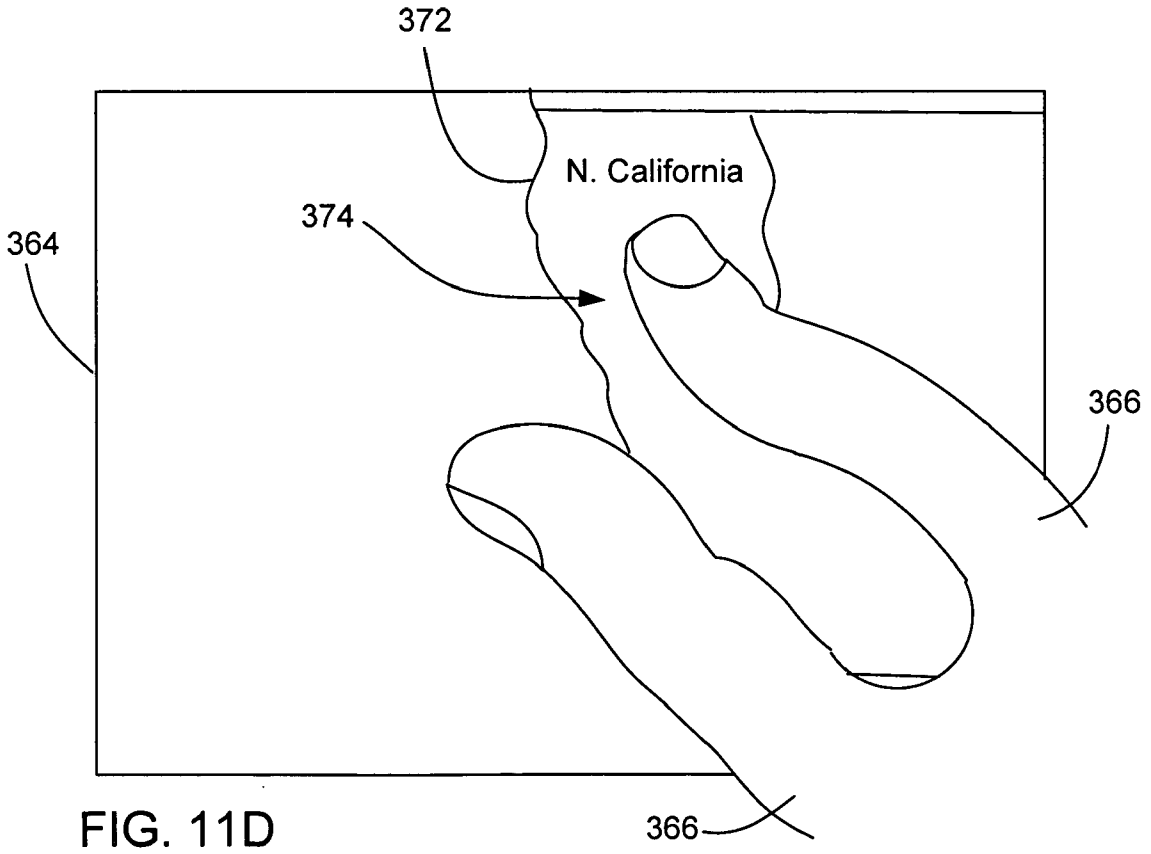


FIG. 11D

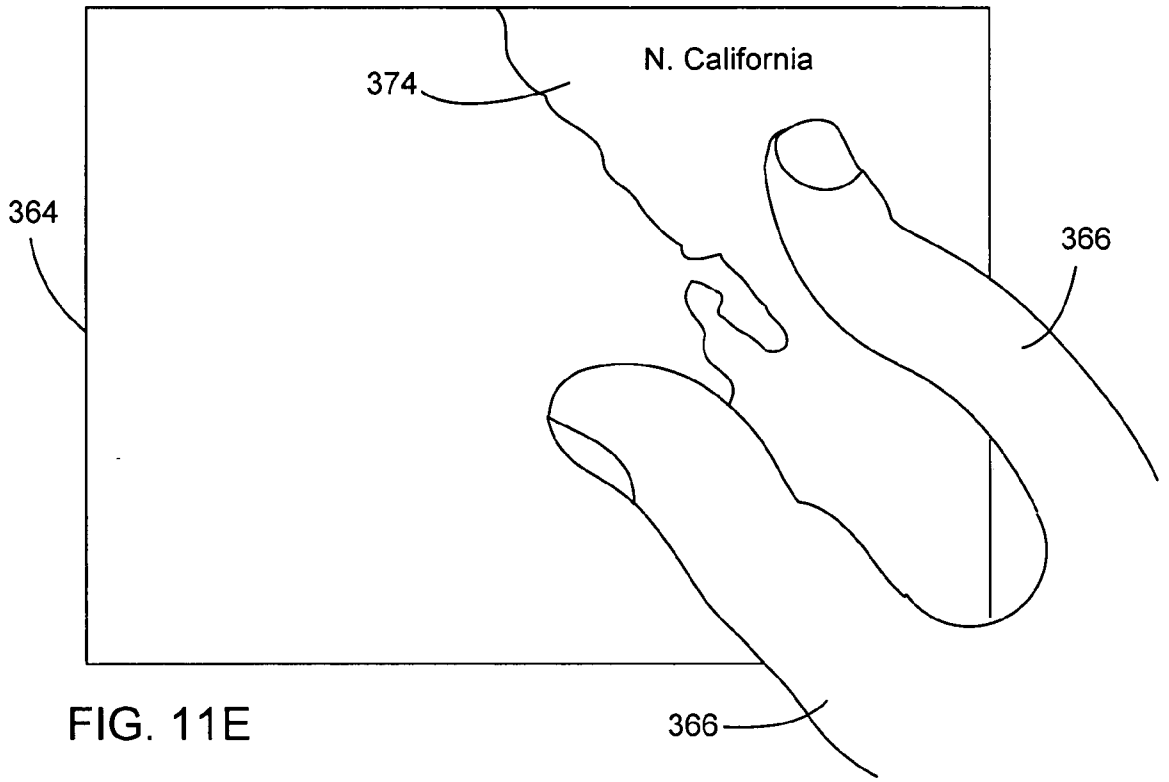


FIG. 11E

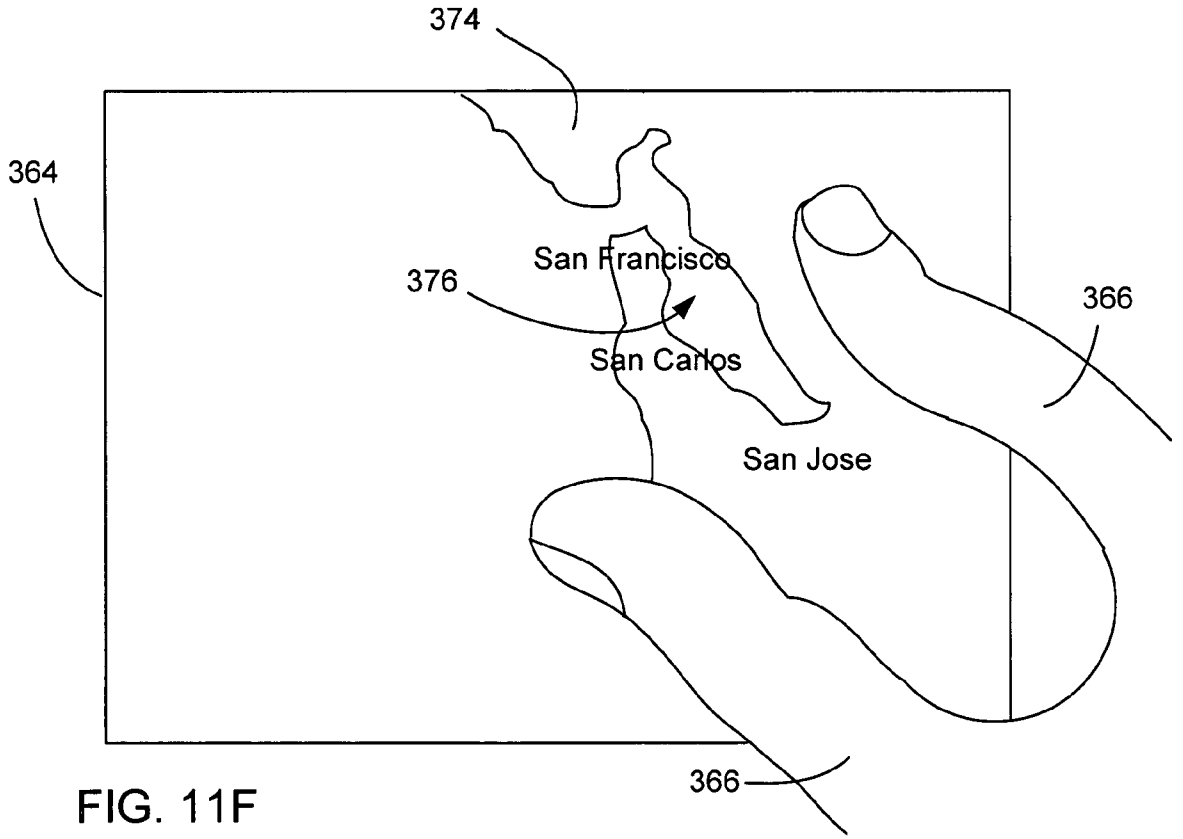


FIG. 11F

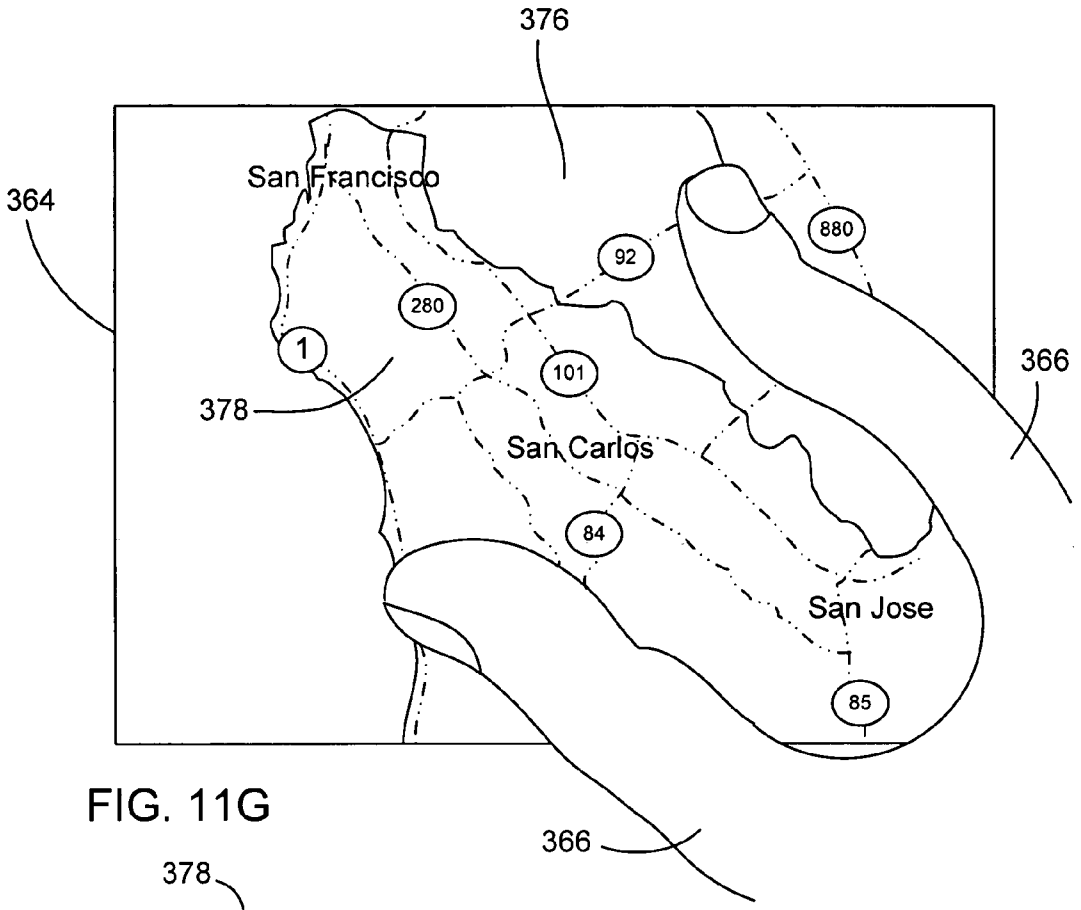


FIG. 11G

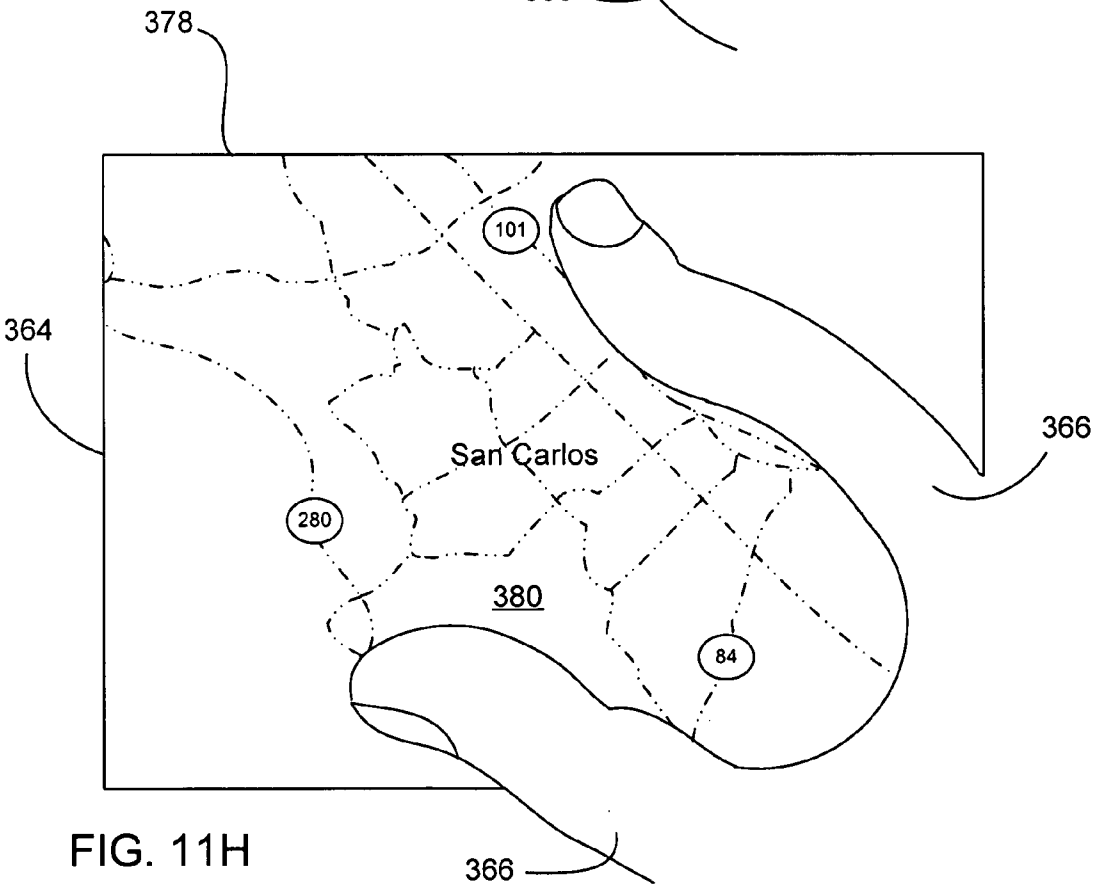


FIG. 11H

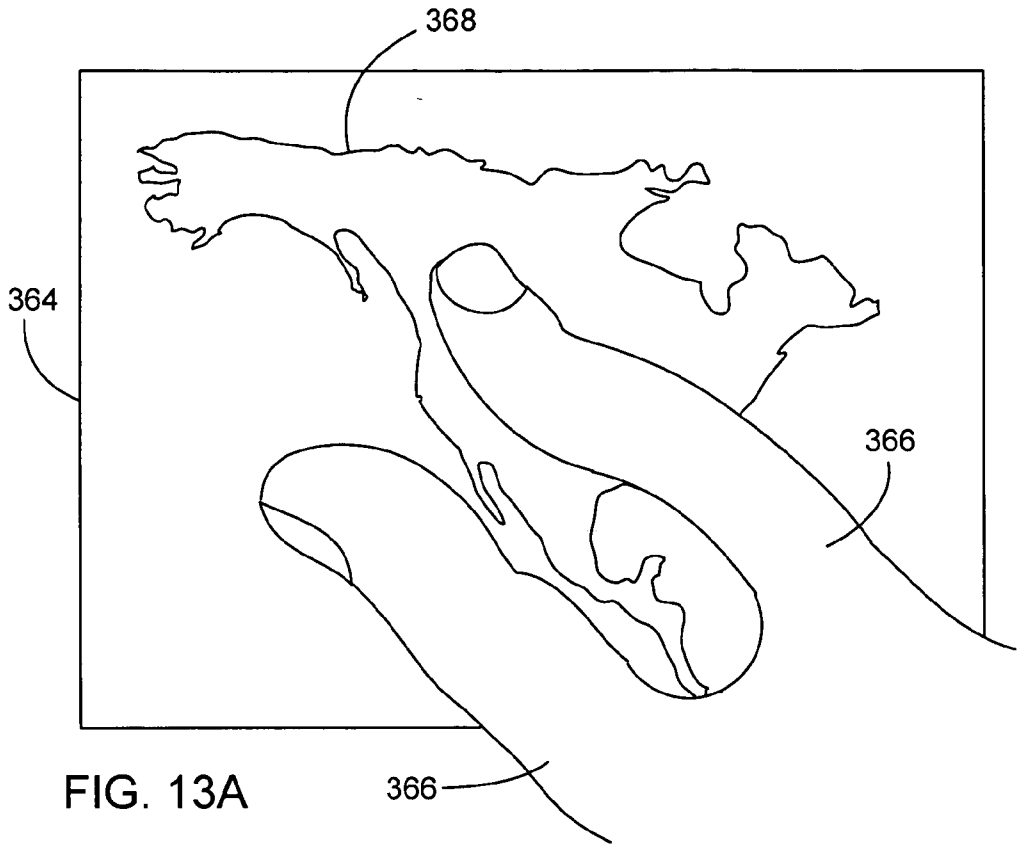


FIG. 13A

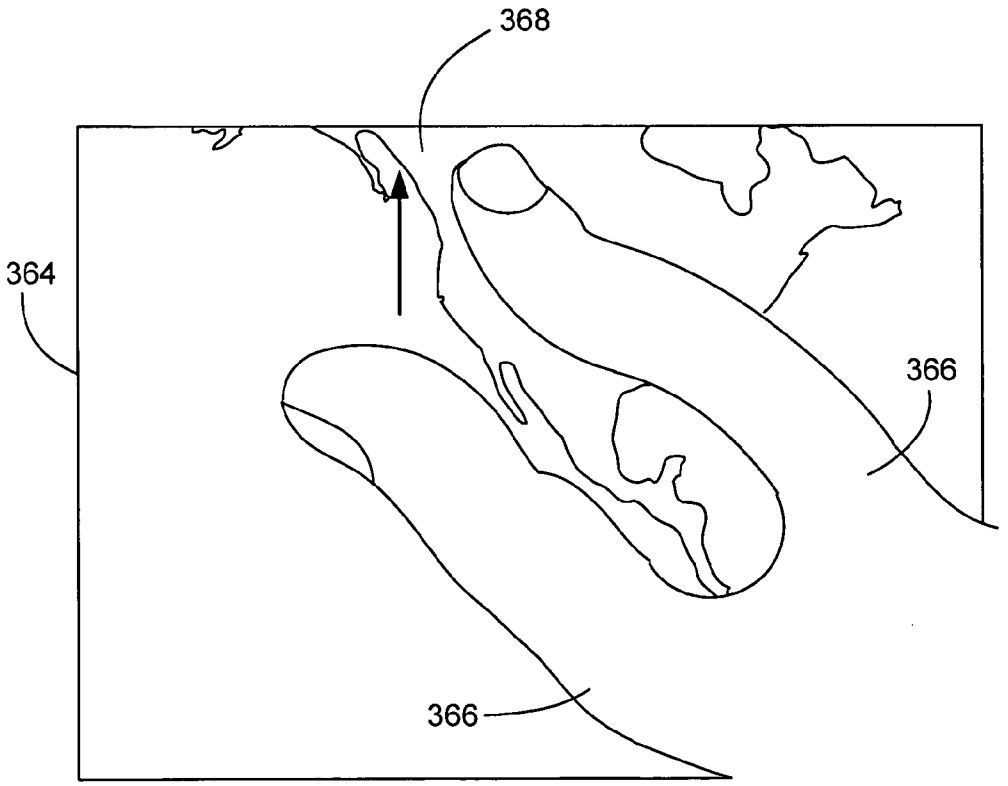


FIG. 13B

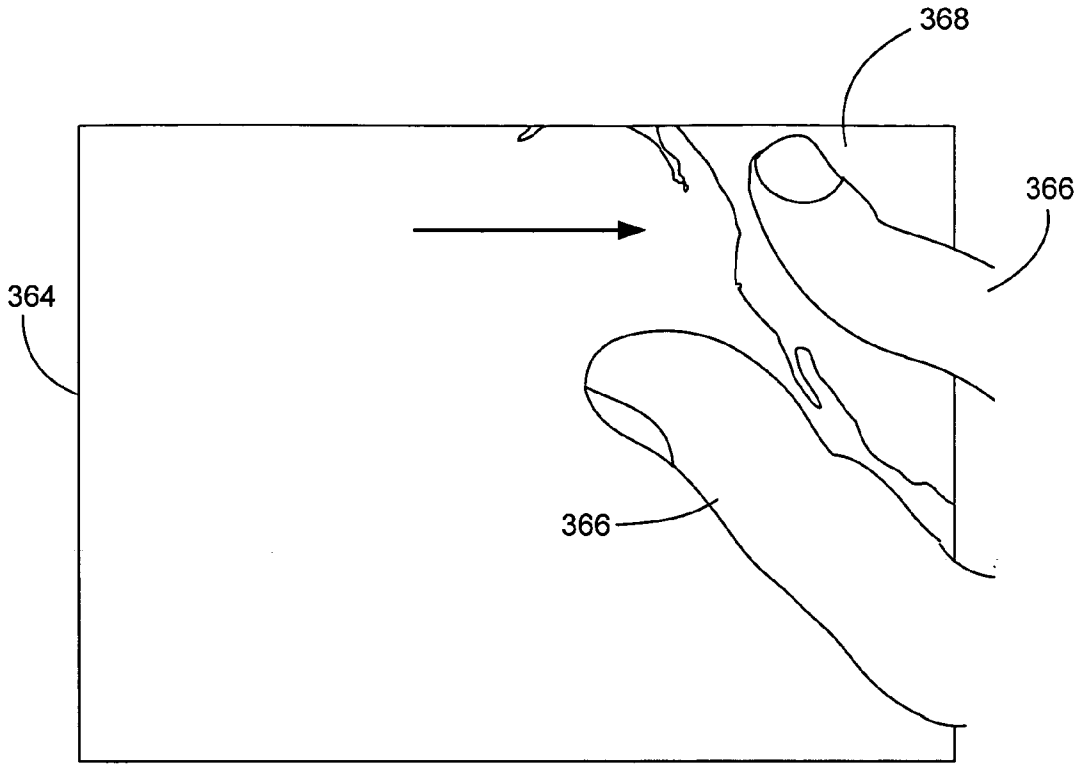


FIG. 13C

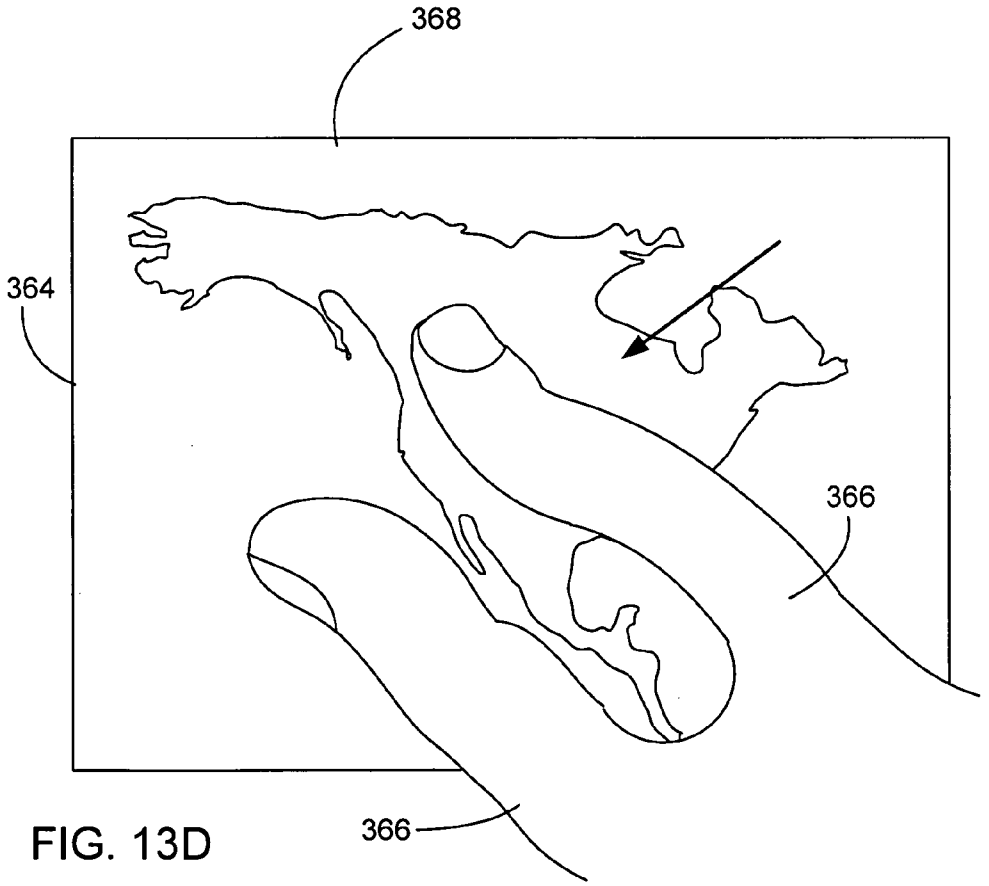


FIG. 13D

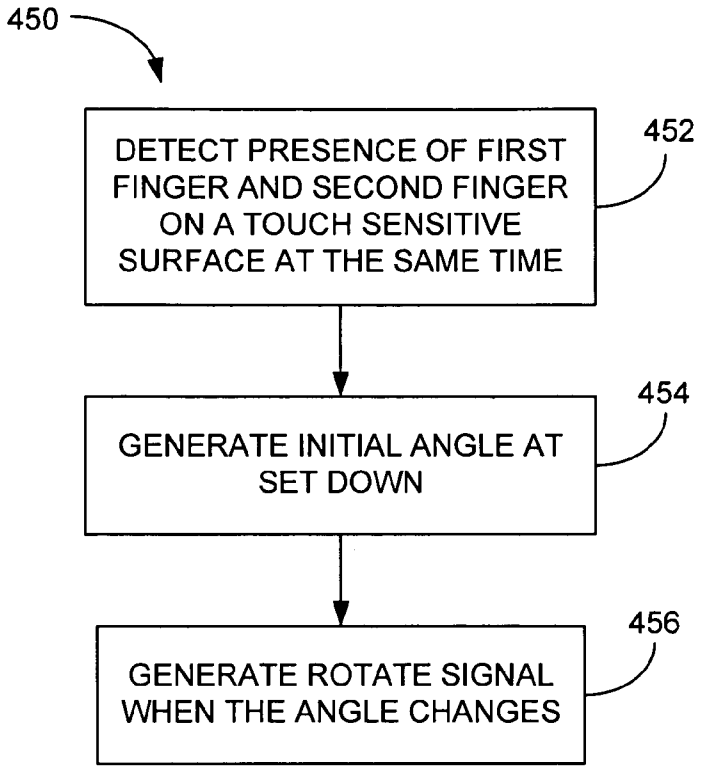

450
DETECT PRESENCE OF FIRST FINGER AND SECOND FINGER ON A TOUCH SENSITIVE SURFACE AT THE SAME TIME
452
GENERATE INITIAL ANGLE AT SET DOWN
454
GENERATE ROTATE SIGNAL WHEN THE ANGLE CHANGES
456

FIG. 14

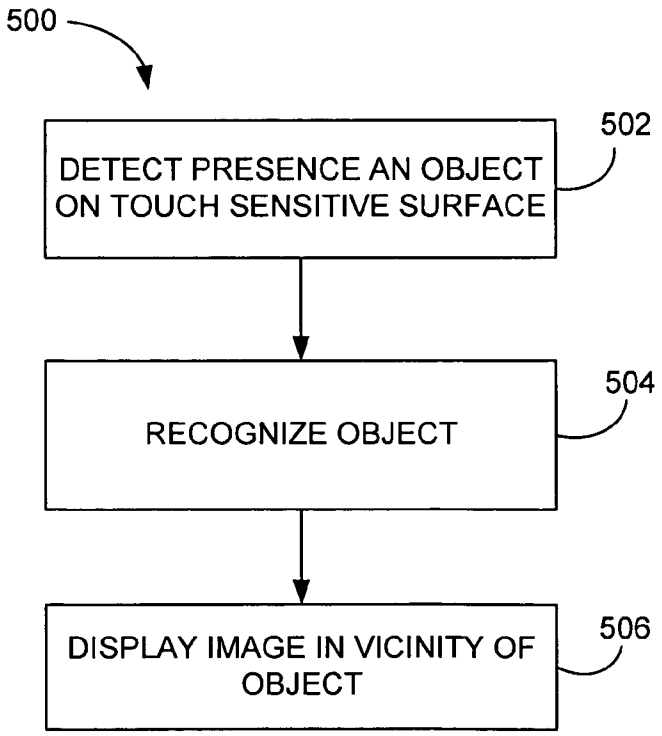

500
DETECT PRESENCE AN OBJECT ON TOUCH SENSITIVE SURFACE
502
RECOGNIZE OBJECT
504
DISPLAY IMAGE IN VICINITY OF OBJECT
506

FIG. 16

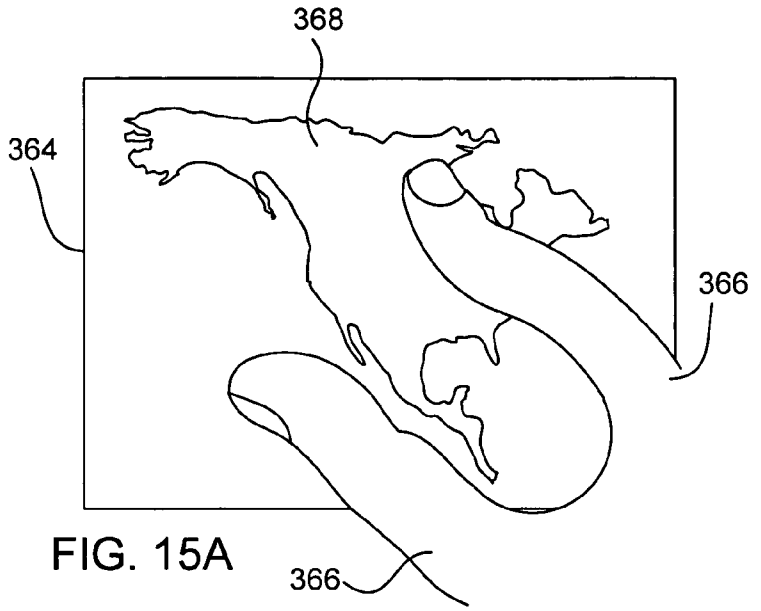


FIG. 15A

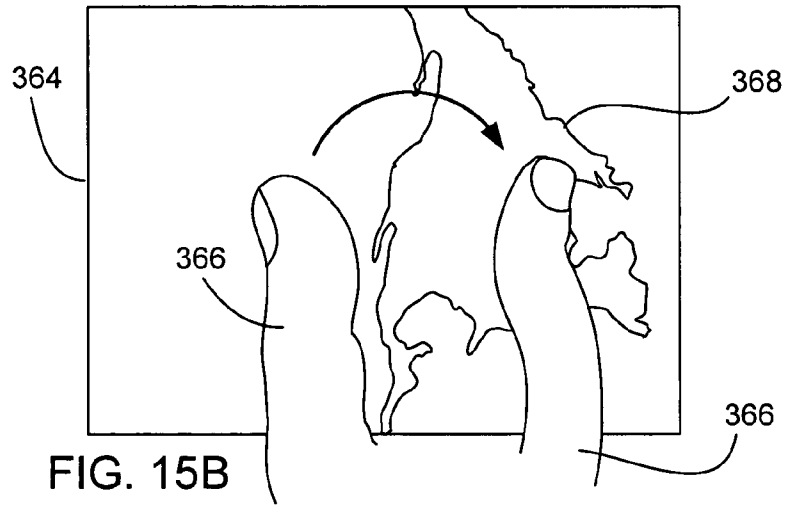


FIG. 15B

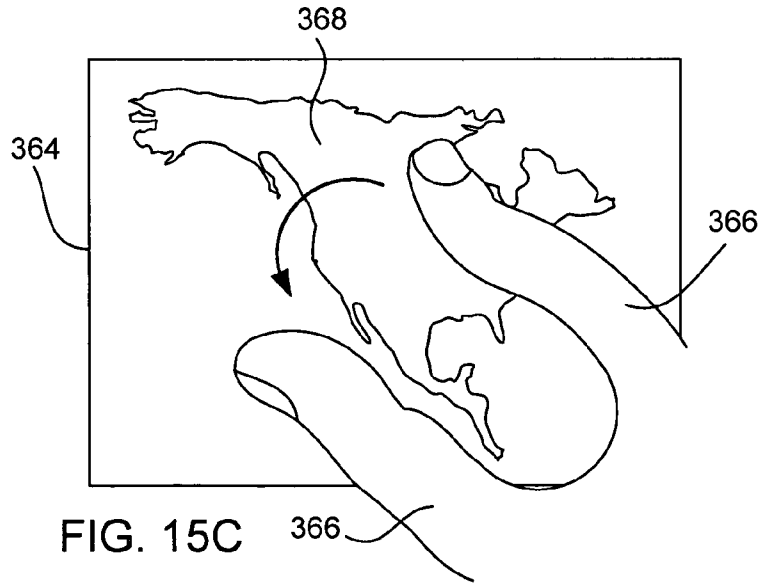


FIG. 15C

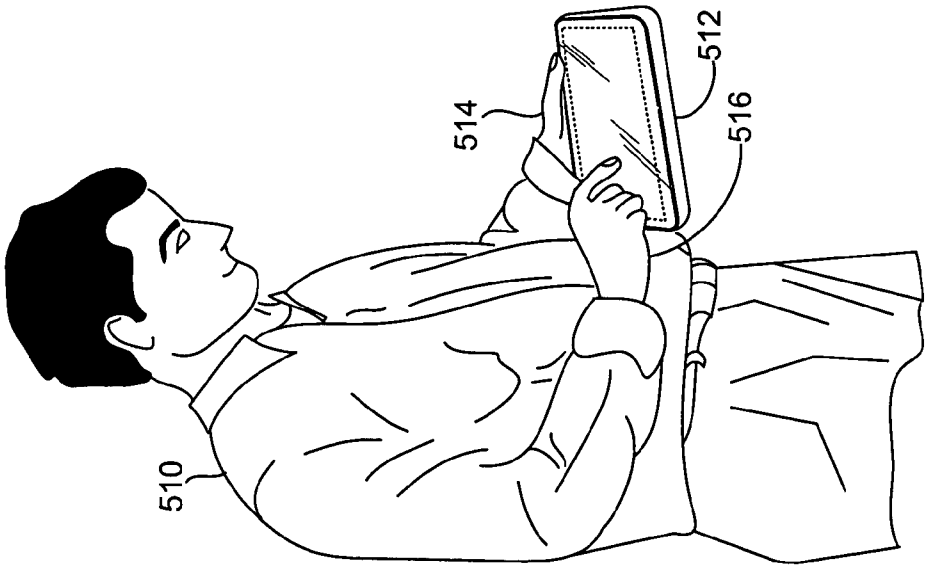


FIG. 17A

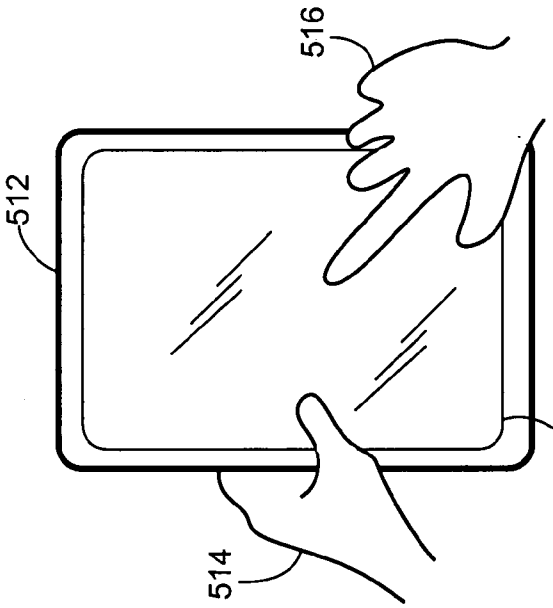


FIG. 17B

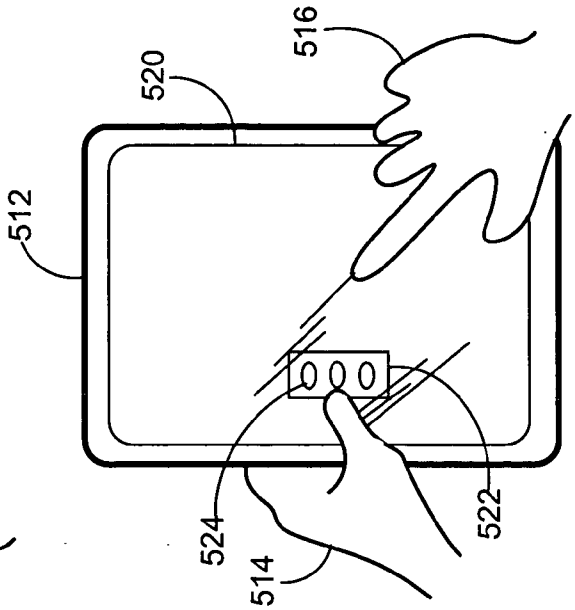


FIG. 17C

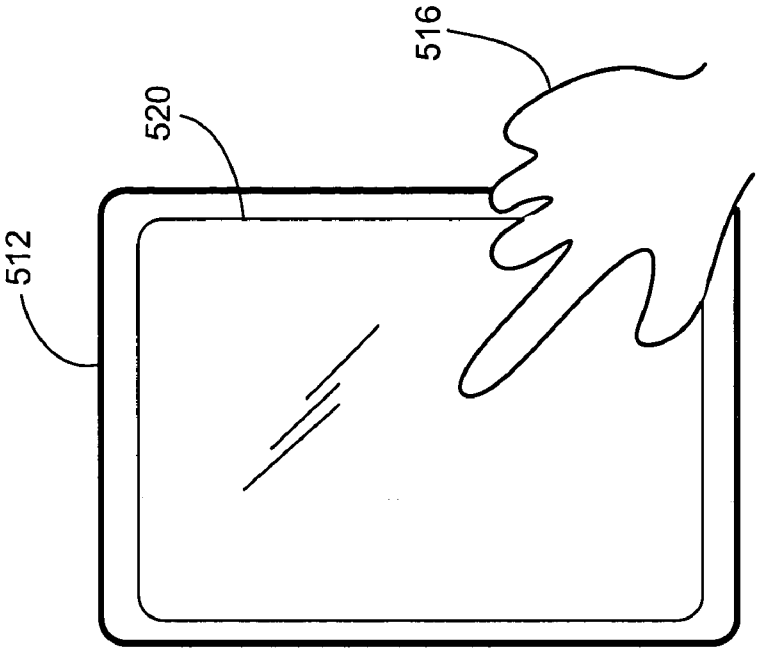


FIG. 17E

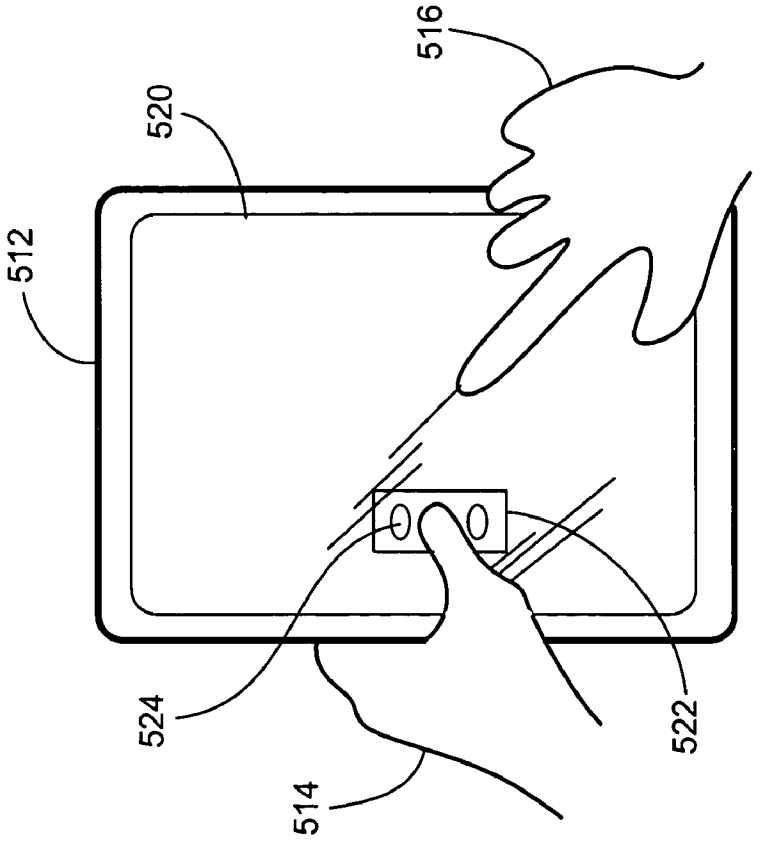


FIG. 17D

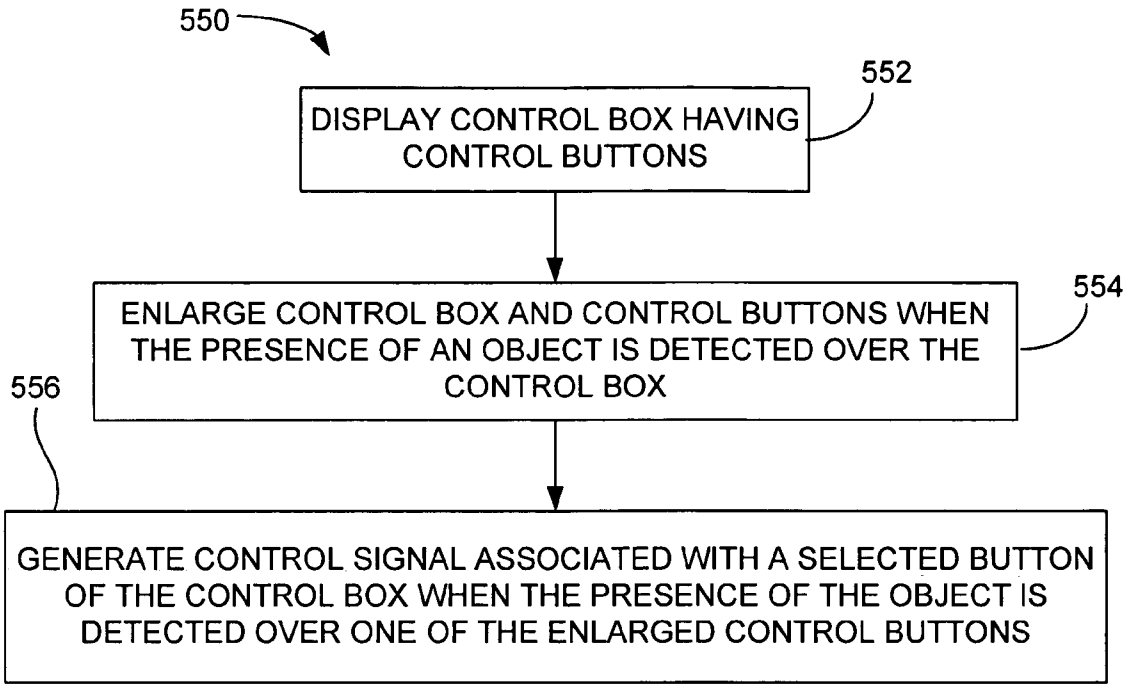

550
552
DISPLAY CONTROL BOX HAVING CONTROL BUTTONS
554
ENLARGE CONTROL BOX AND CONTROL BUTTONS WHEN THE PRESENCE OF AN OBJECT IS DETECTED OVER THE CONTROL BOX
556
GENERATE CONTROL SIGNAL ASSOCIATED WITH A SELECTED BUTTON OF THE CONTROL BOX WHEN THE PRESENCE OF THE OBJECT IS DETECTED OVER ONE OF THE ENLARGED CONTROL BUTTONS

FIG. 18

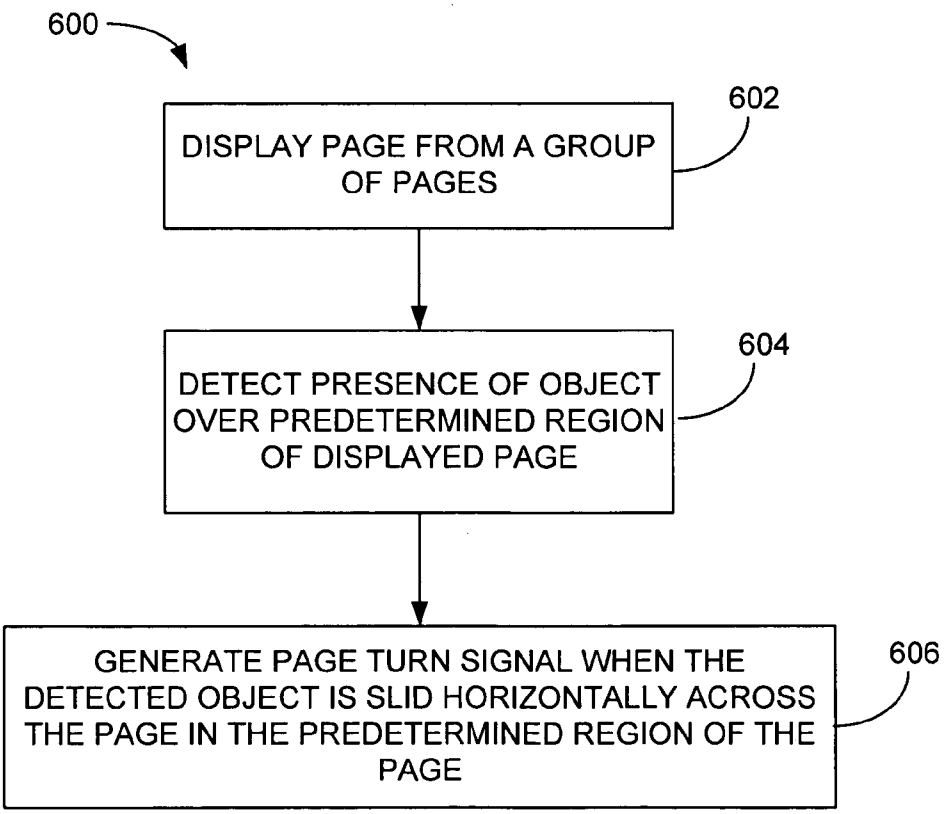

600
602
DISPLAY PAGE FROM A GROUP OF PAGES
604
DETECT PRESENCE OF OBJECT OVER PREDETERMINED REGION OF DISPLAYED PAGE
606
GENERATE PAGE TURN SIGNAL WHEN THE DETECTED OBJECT IS SLID HORIZONTALLY ACROSS THE PAGE IN THE PREDETERMINED REGION OF THE PAGE

FIG. 20

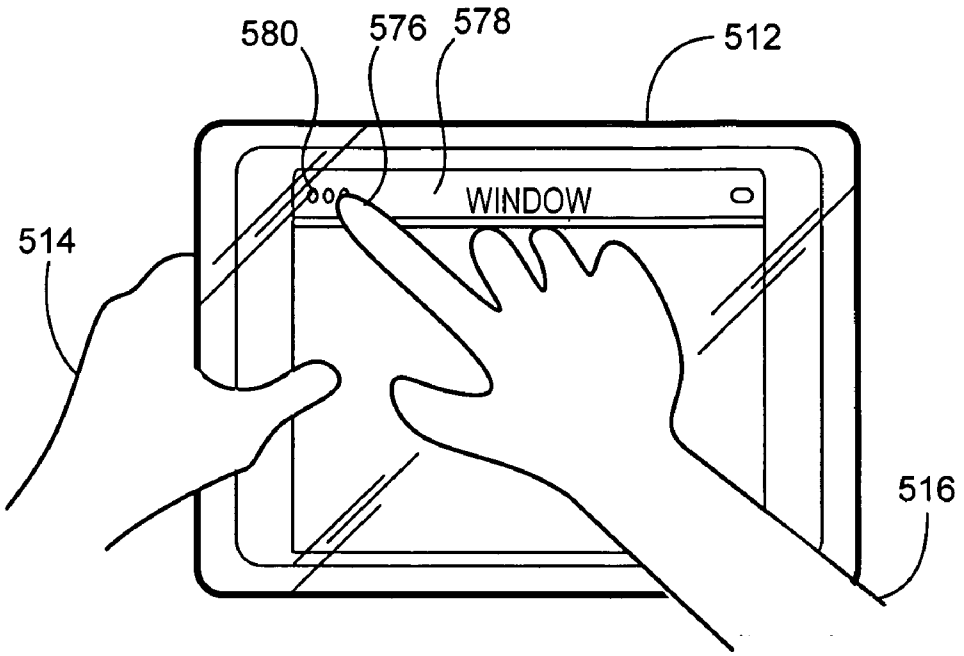


FIG. 19A

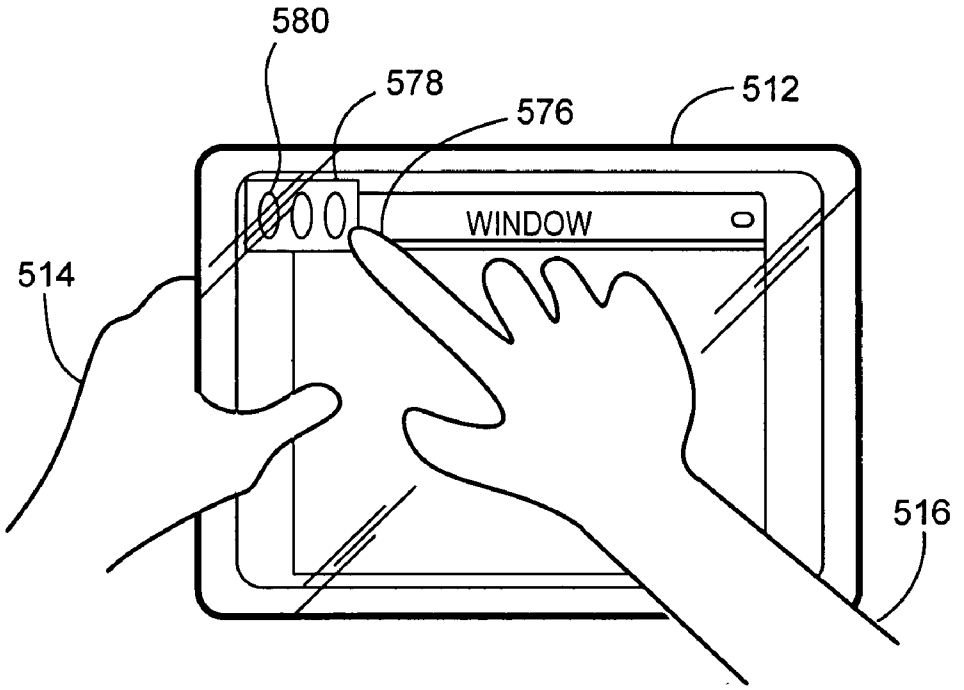


FIG. 19B

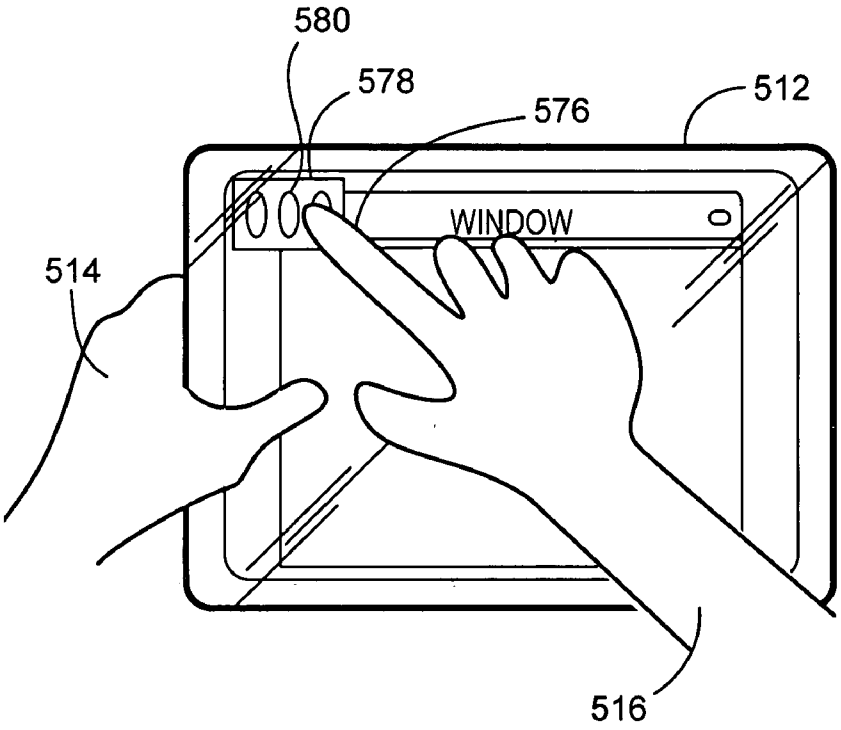


FIG. 19C

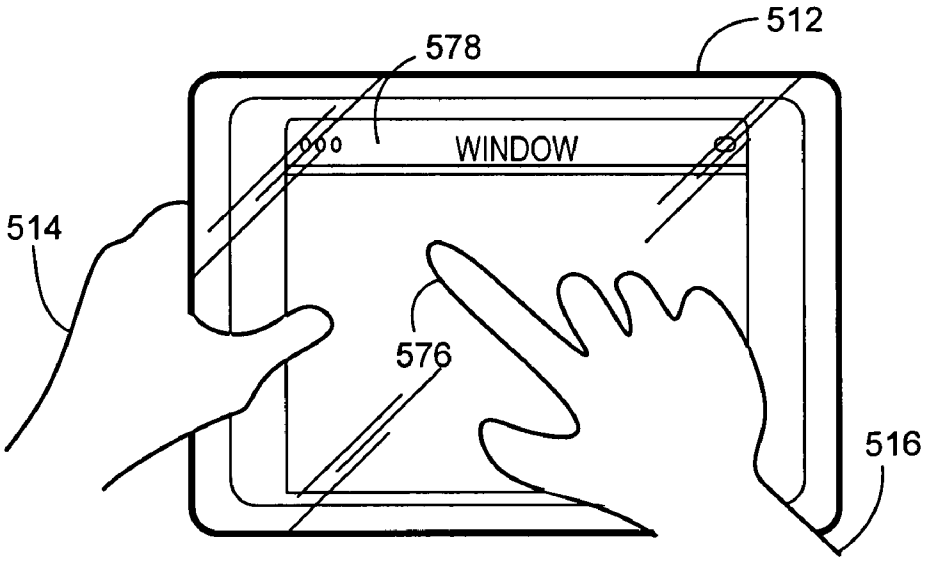


FIG. 19D

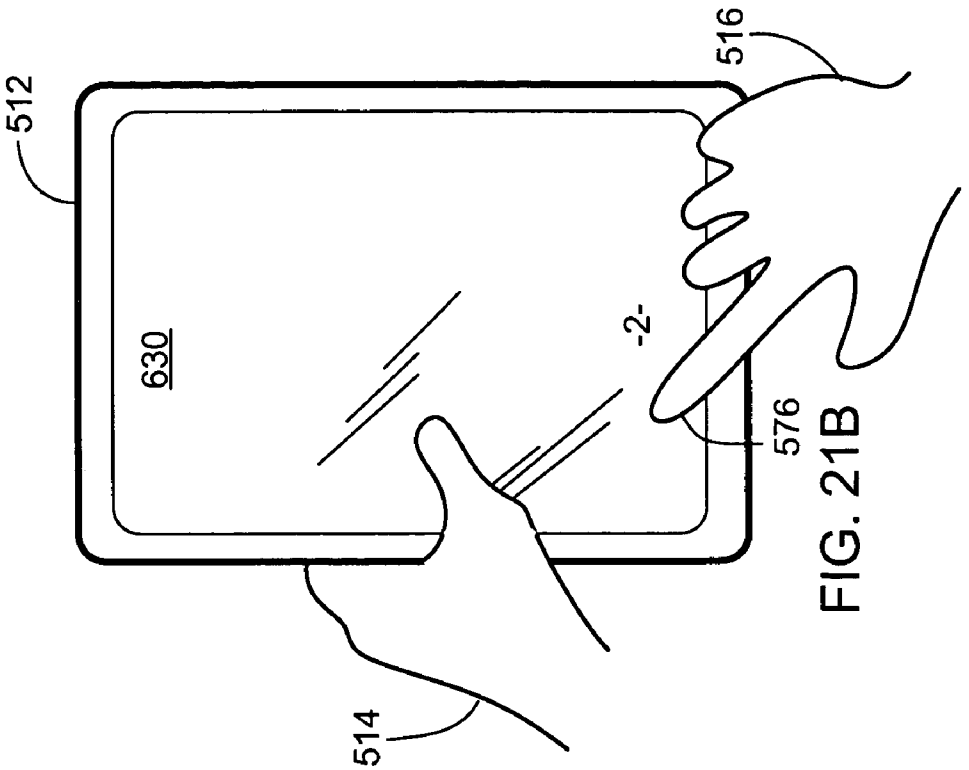


FIG. 21B

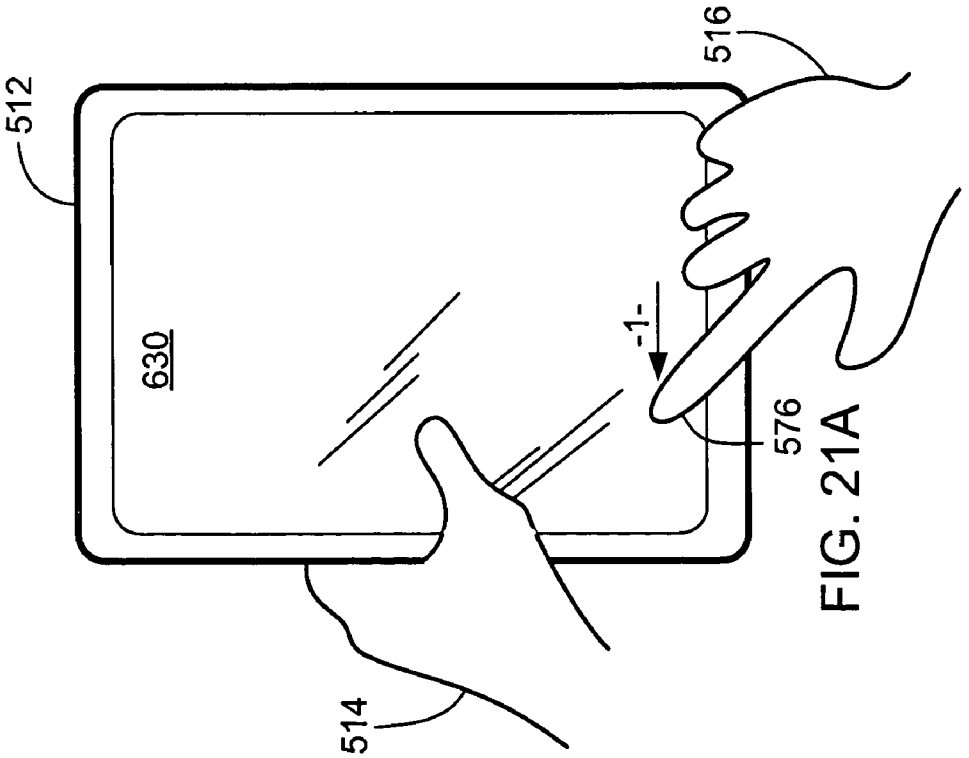


FIG. 21A

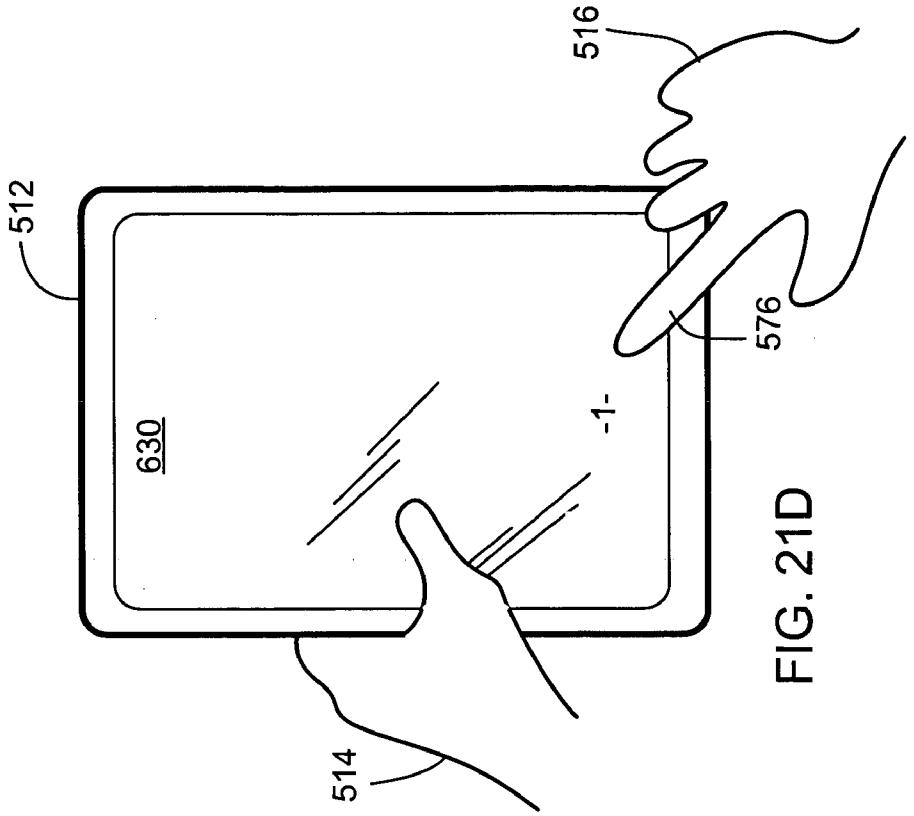


FIG. 21D

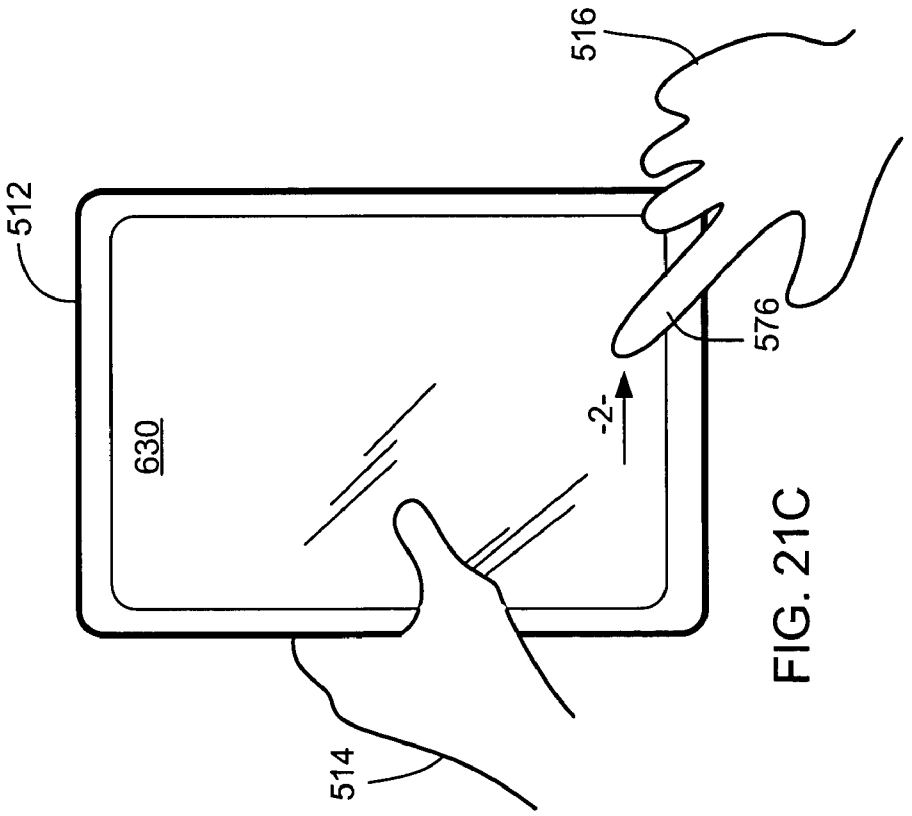


FIG. 21C

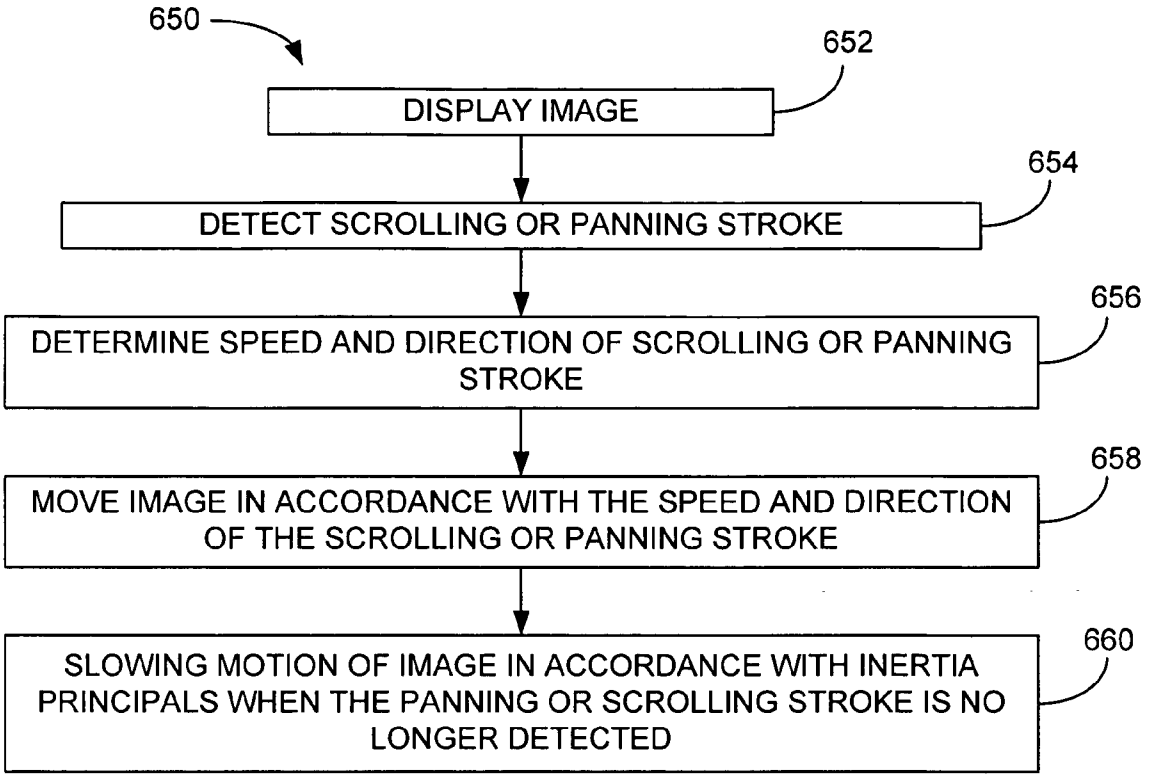

650
652
DISPLAY IMAGE
654
DETECT SCROLLING OR PANNING STROKE
656
DETERMINE SPEED AND DIRECTION OF SCROLLING OR PANNING STROKE
658
MOVE IMAGE IN ACCORDANCE WITH THE SPEED AND DIRECTION OF THE SCROLLING OR PANNING STROKE
660
SLOWING MOTION OF IMAGE IN ACCORDANCE WITH INERTIA PRINCIPALS WHEN THE PANNING OR SCROLLING STROKE IS NO LONGER DETECTED

FIG. 22

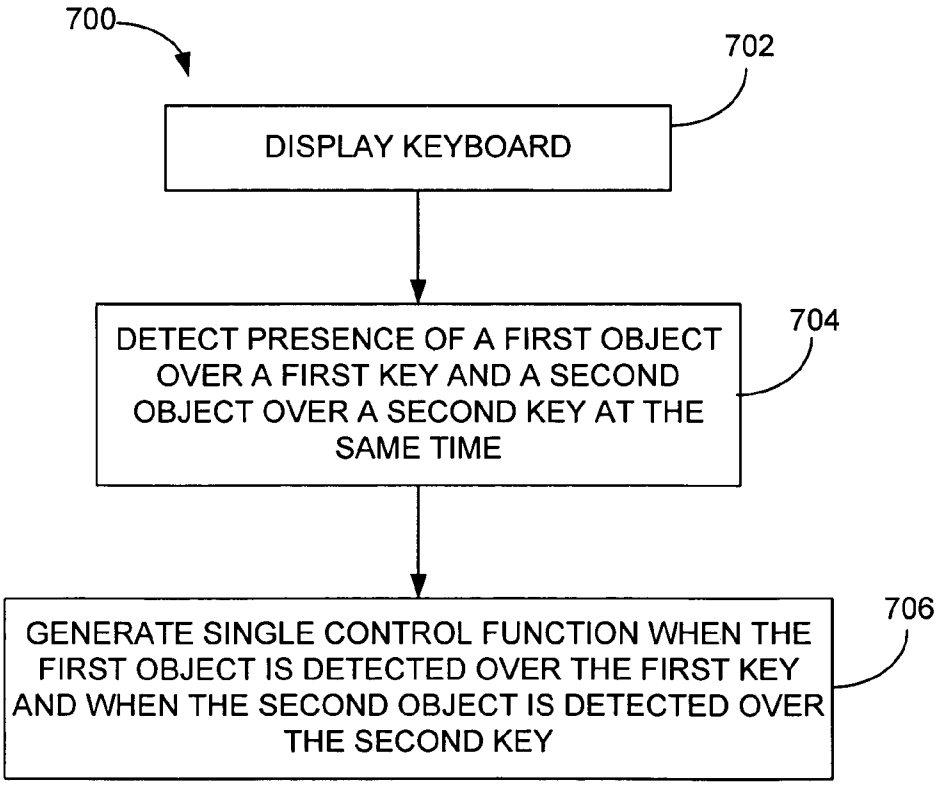

700
702
DISPLAY KEYBOARD
704
DETECT PRESENCE OF A FIRST OBJECT OVER A FIRST KEY AND A SECOND OBJECT OVER A SECOND KEY AT THE SAME TIME
706
GENERATE SINGLE CONTROL FUNCTION WHEN THE FIRST OBJECT IS DETECTED OVER THE FIRST KEY AND WHEN THE SECOND OBJECT IS DETECTED OVER THE SECOND KEY

FIG. 24

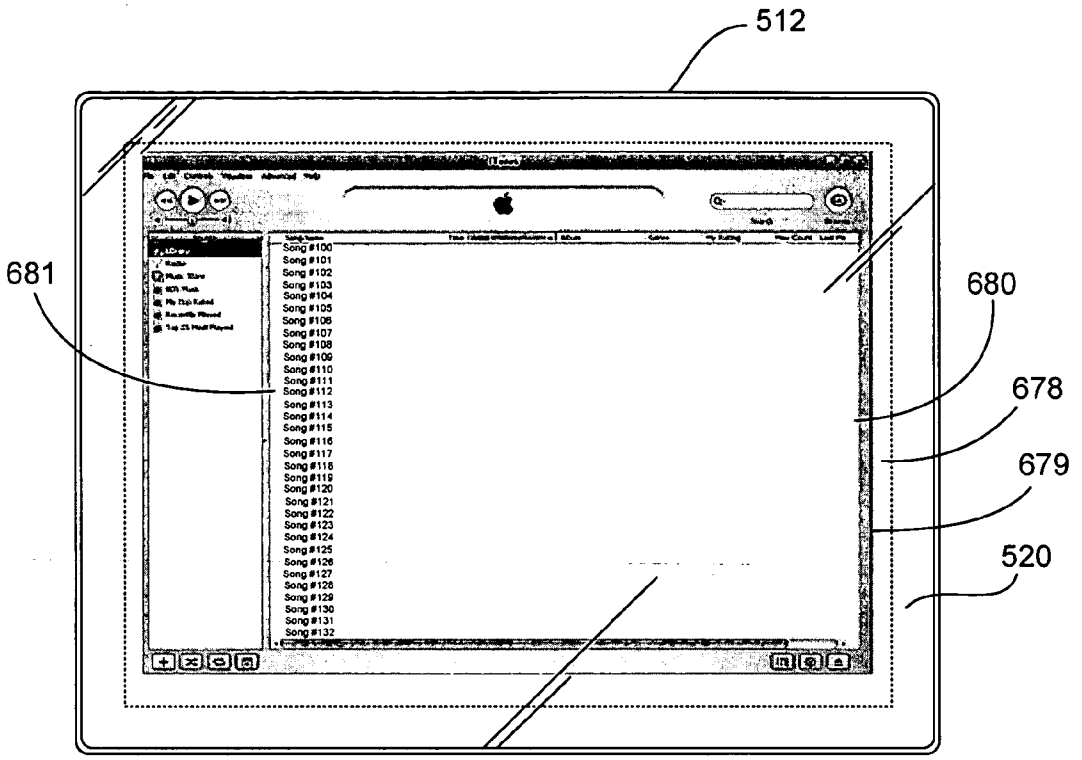


FIG. 23A

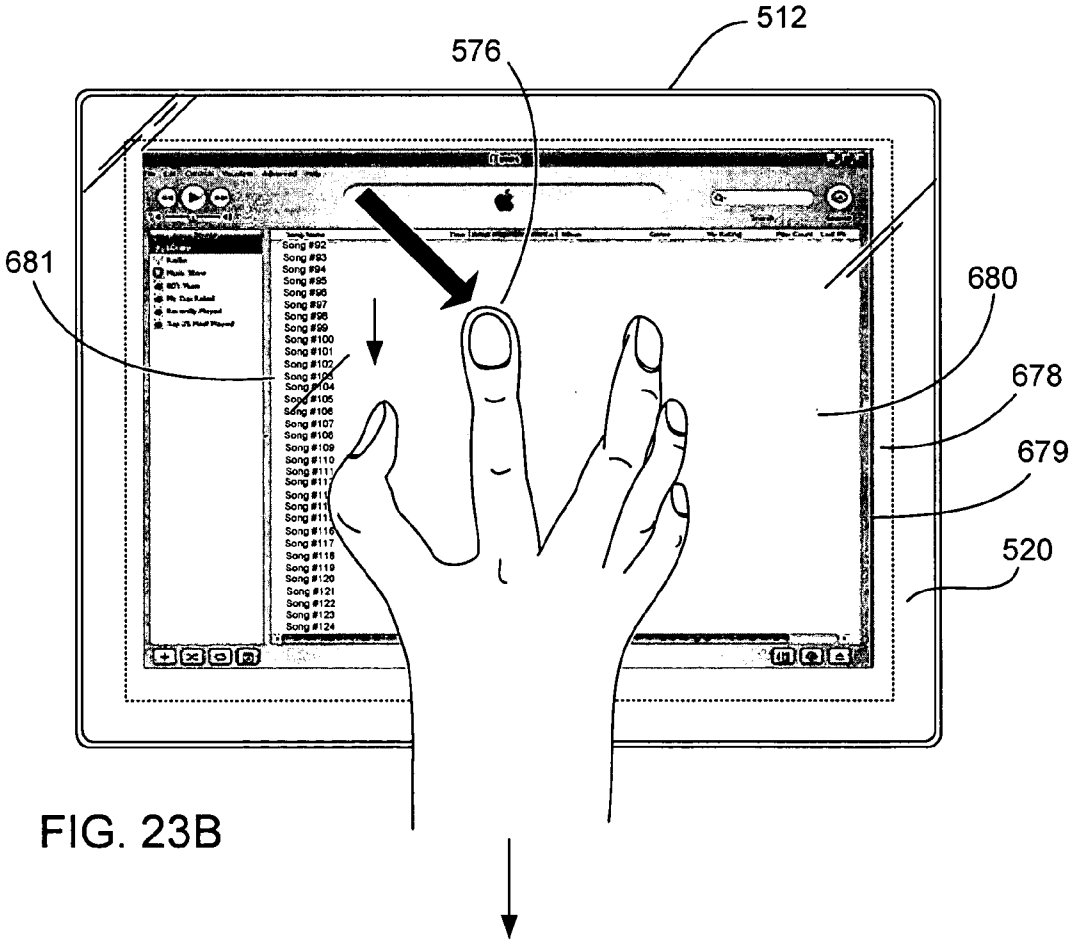


FIG. 23B

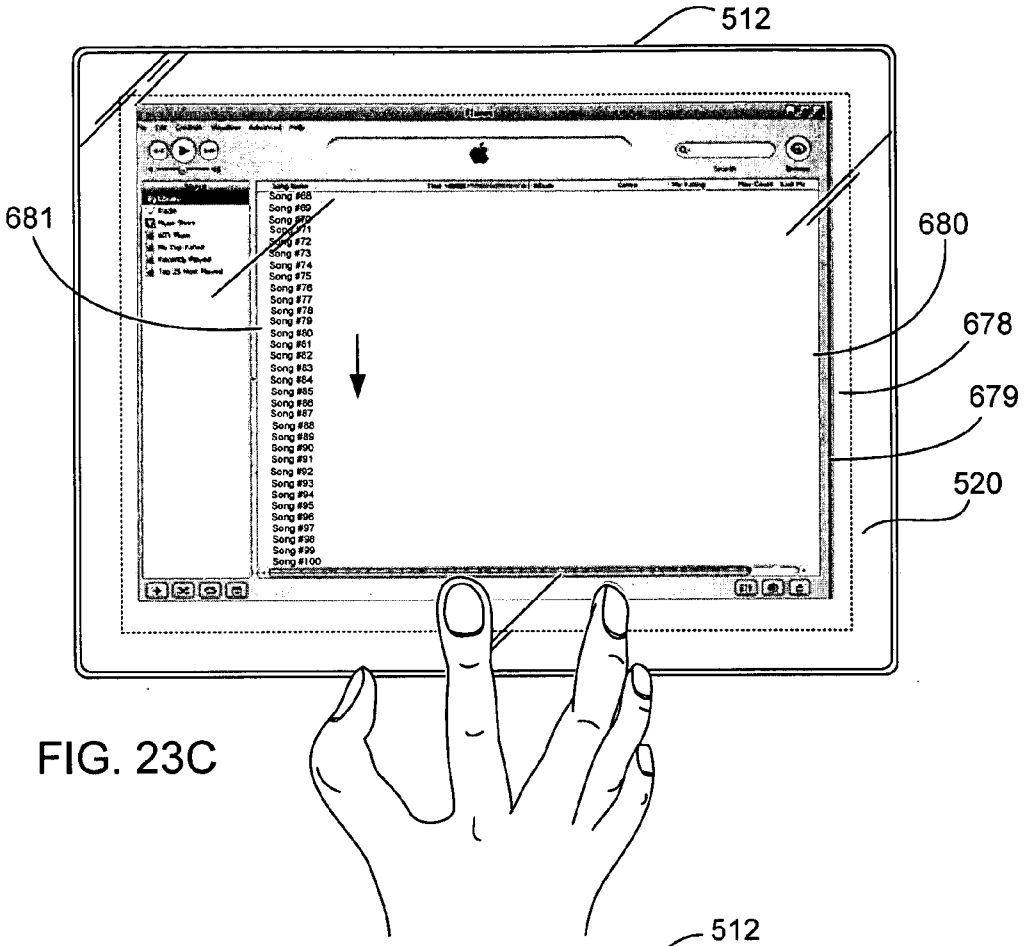


FIG. 23C

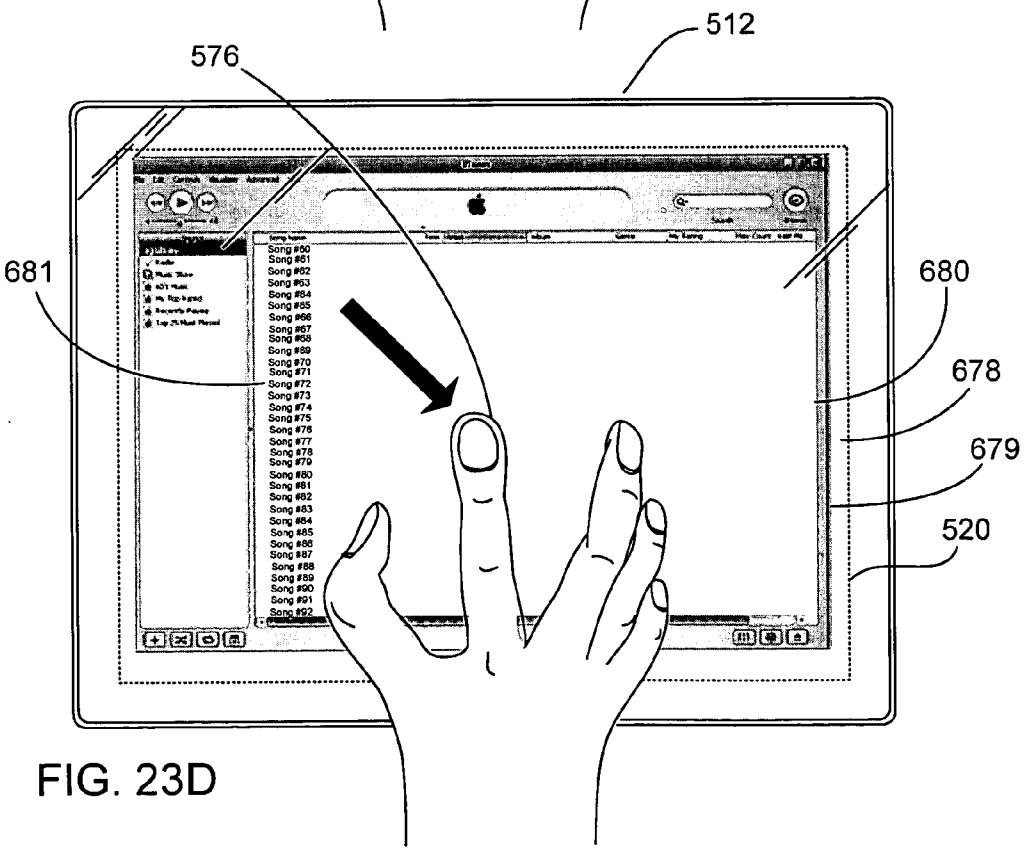


FIG. 23D

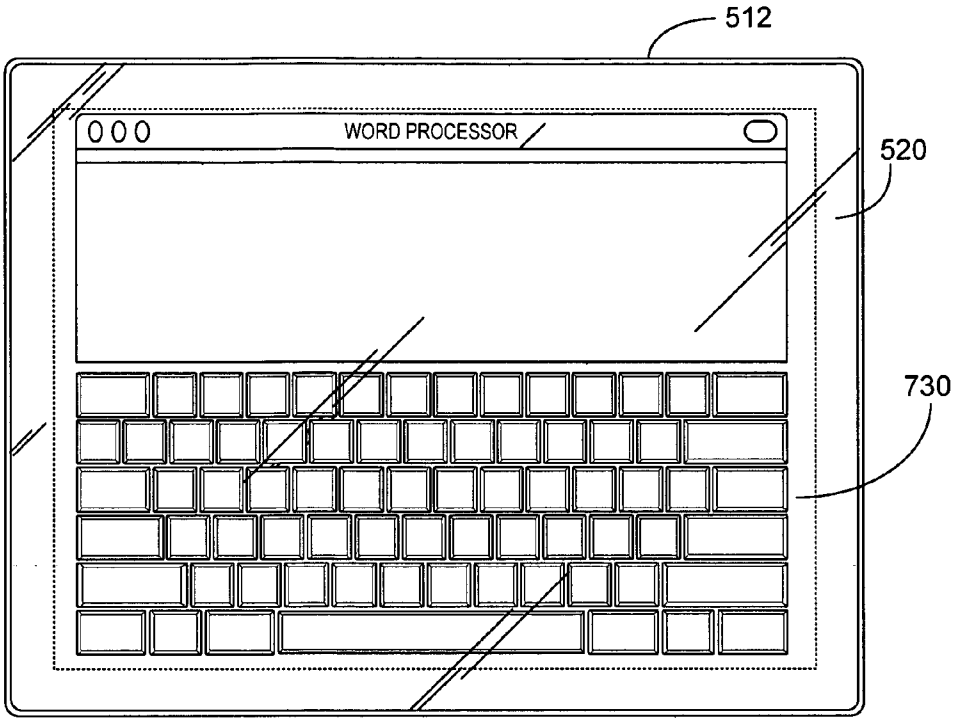


FIG. 25A

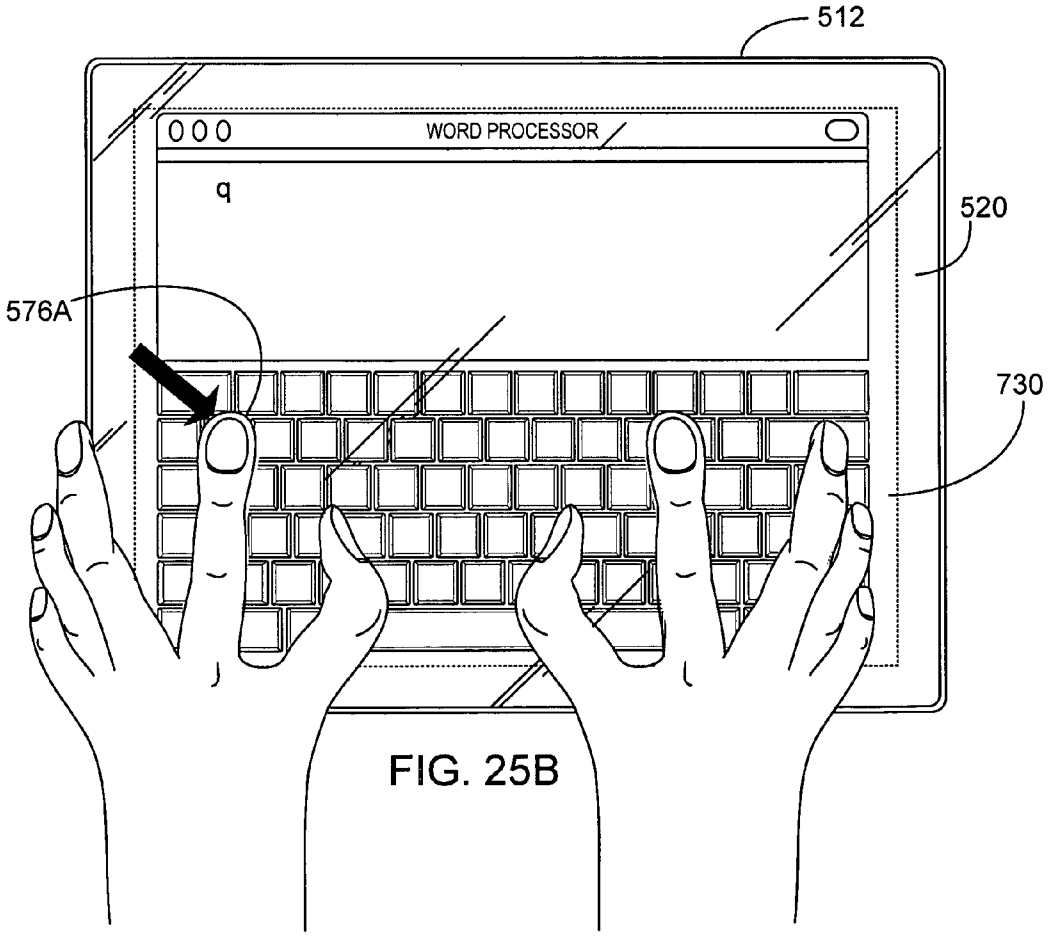


FIG. 25B

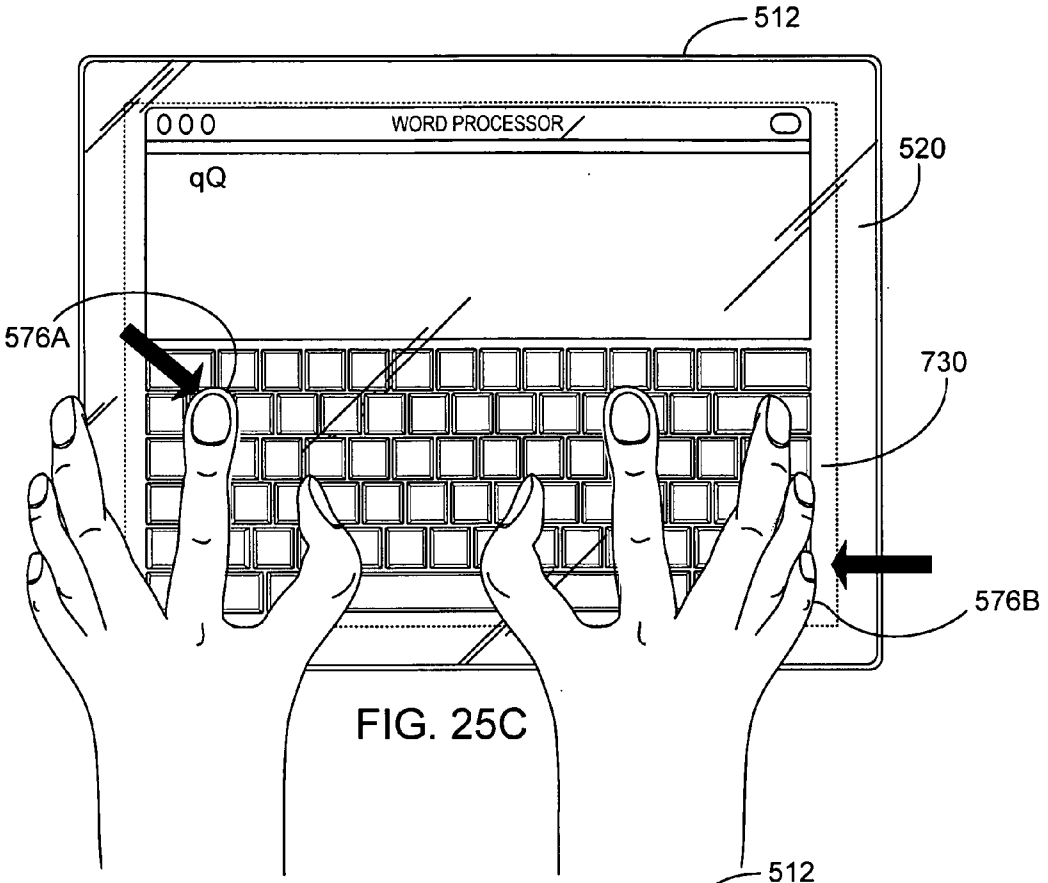


FIG. 25C

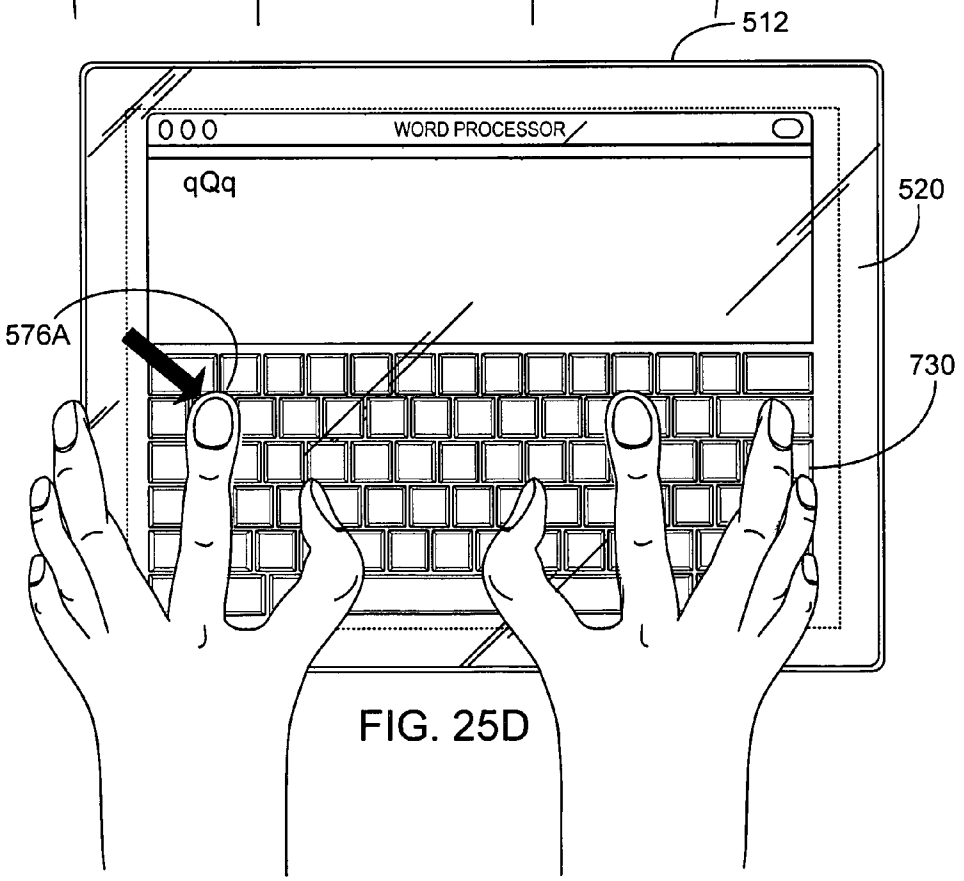


FIG. 25D

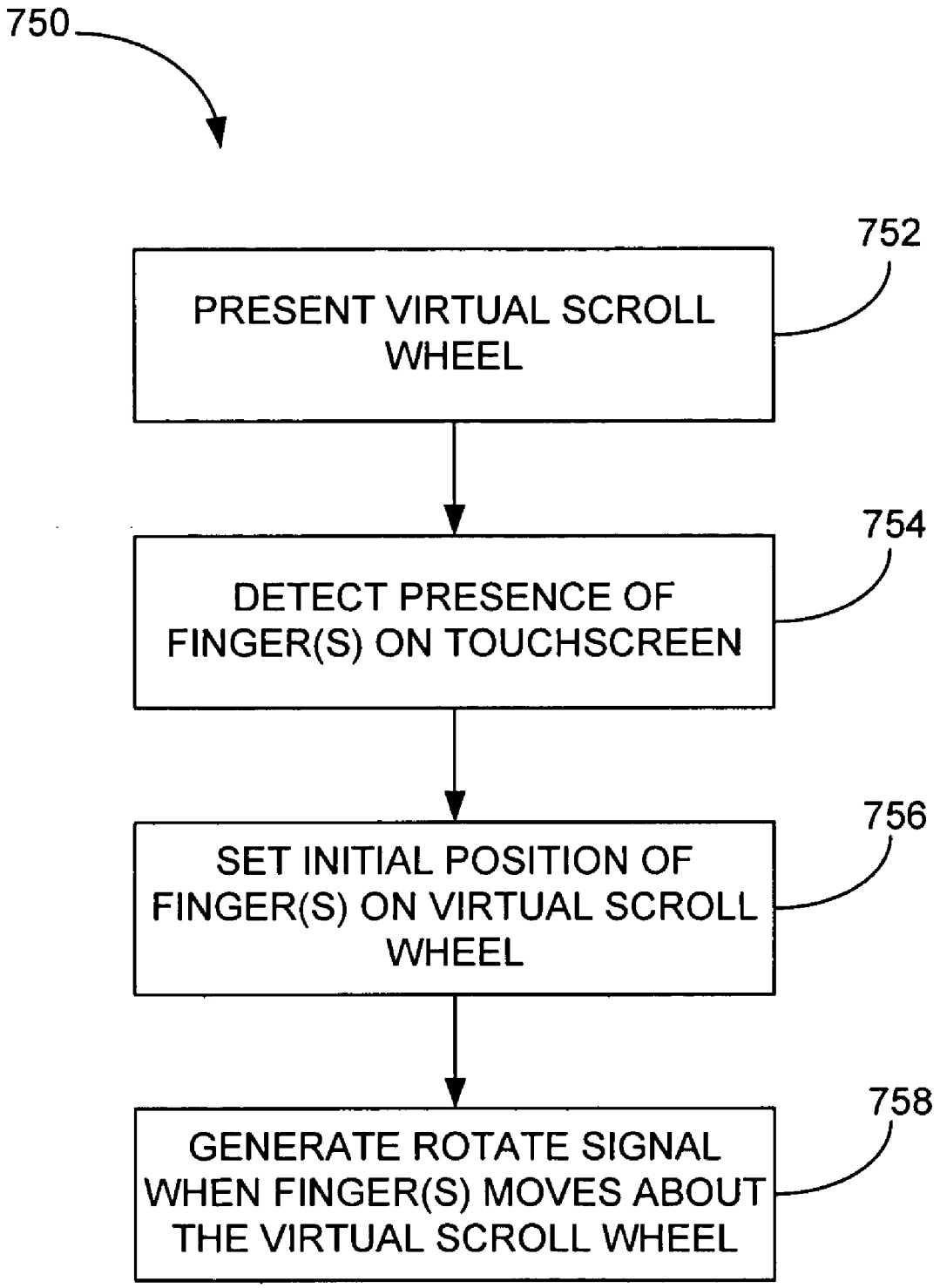

750
752
PRESENT VIRTUAL SCROLL WHEEL
754
DETECT PRESENCE OF FINGER(S) ON TOUCHSCREEN
756
SET INITIAL POSITION OF FINGER(S) ON VIRTUAL SCROLL WHEEL
758
GENERATE ROTATE SIGNAL WHEN FINGER(S) MOVES ABOUT THE VIRTUAL SCROLL WHEEL

FIG. 26

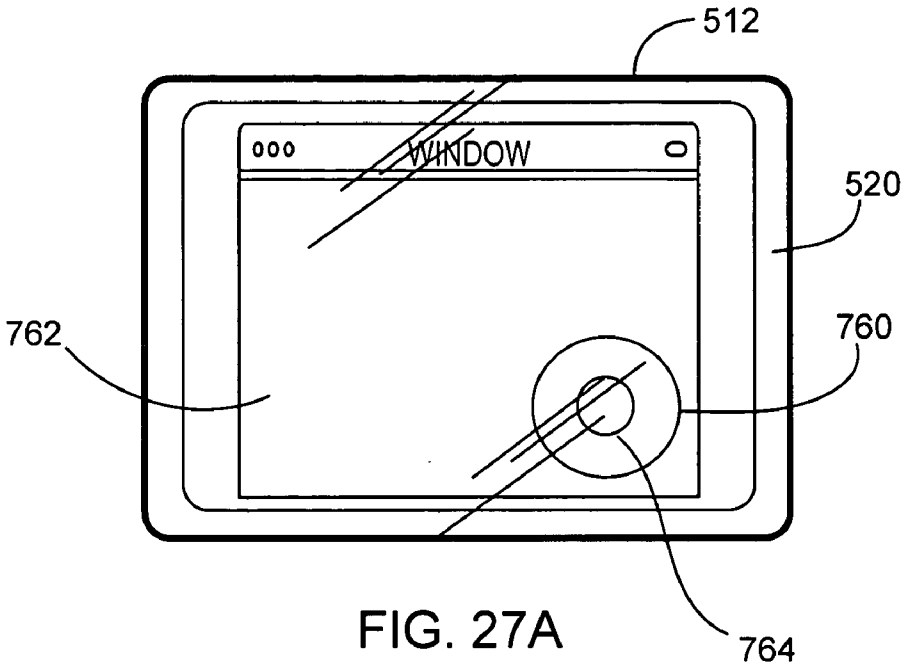


FIG. 27A

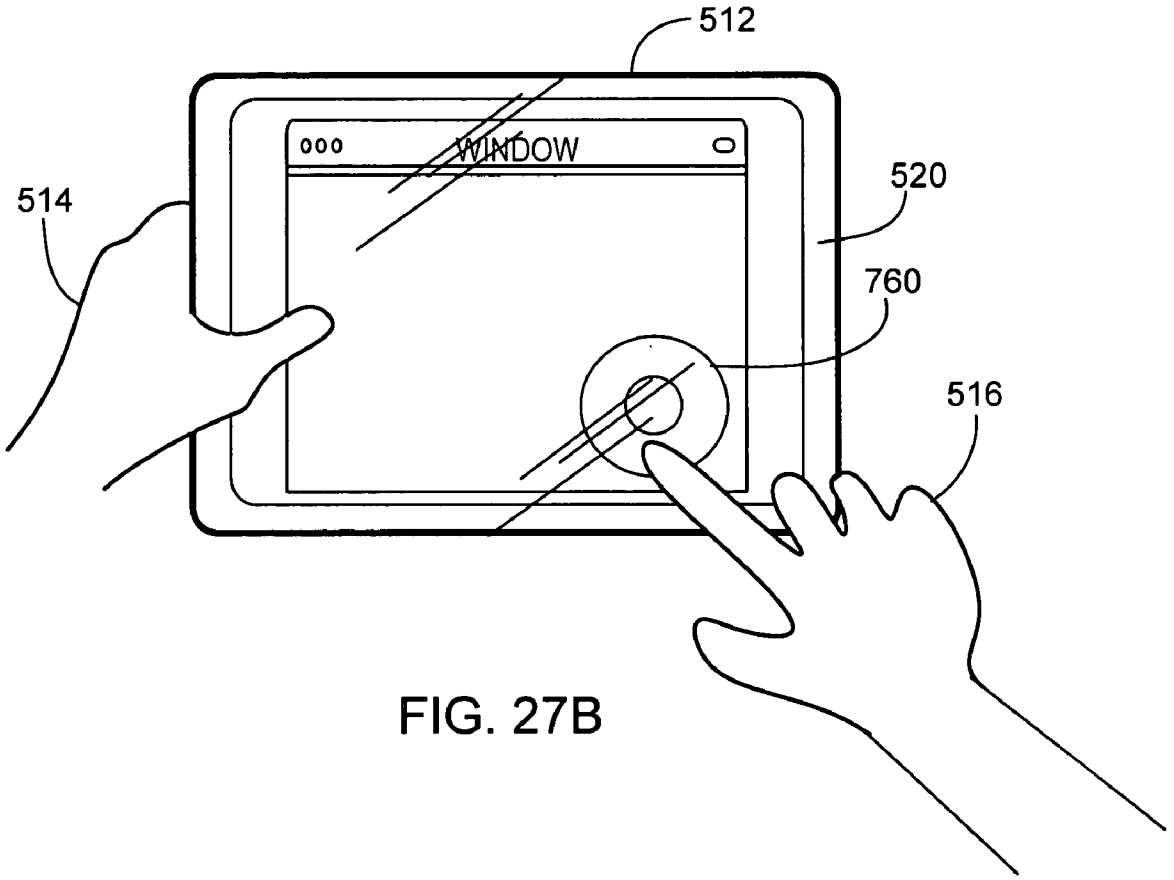


FIG. 27B

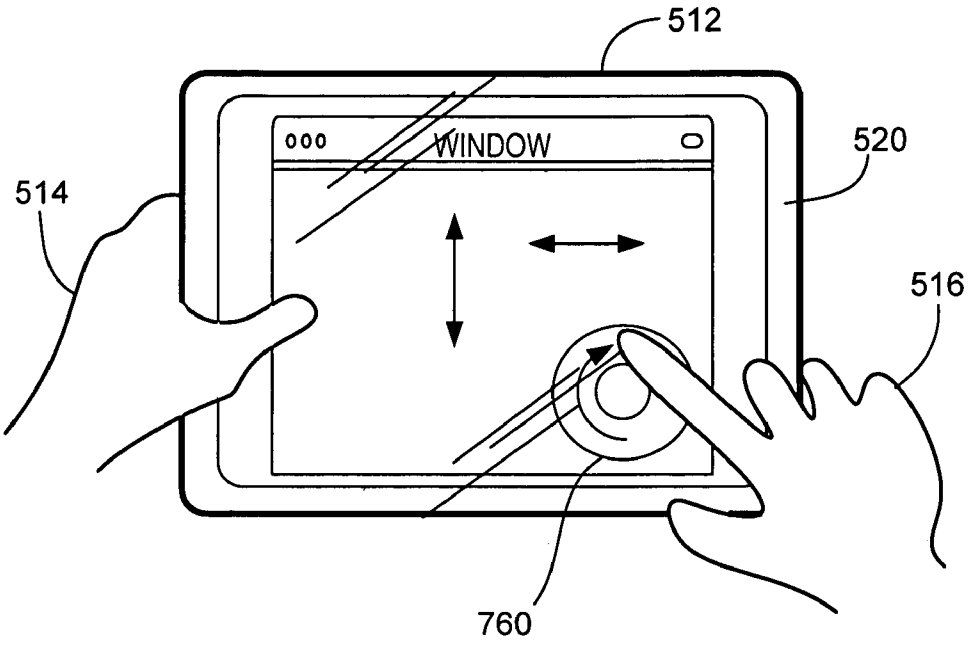


FIG. 27C

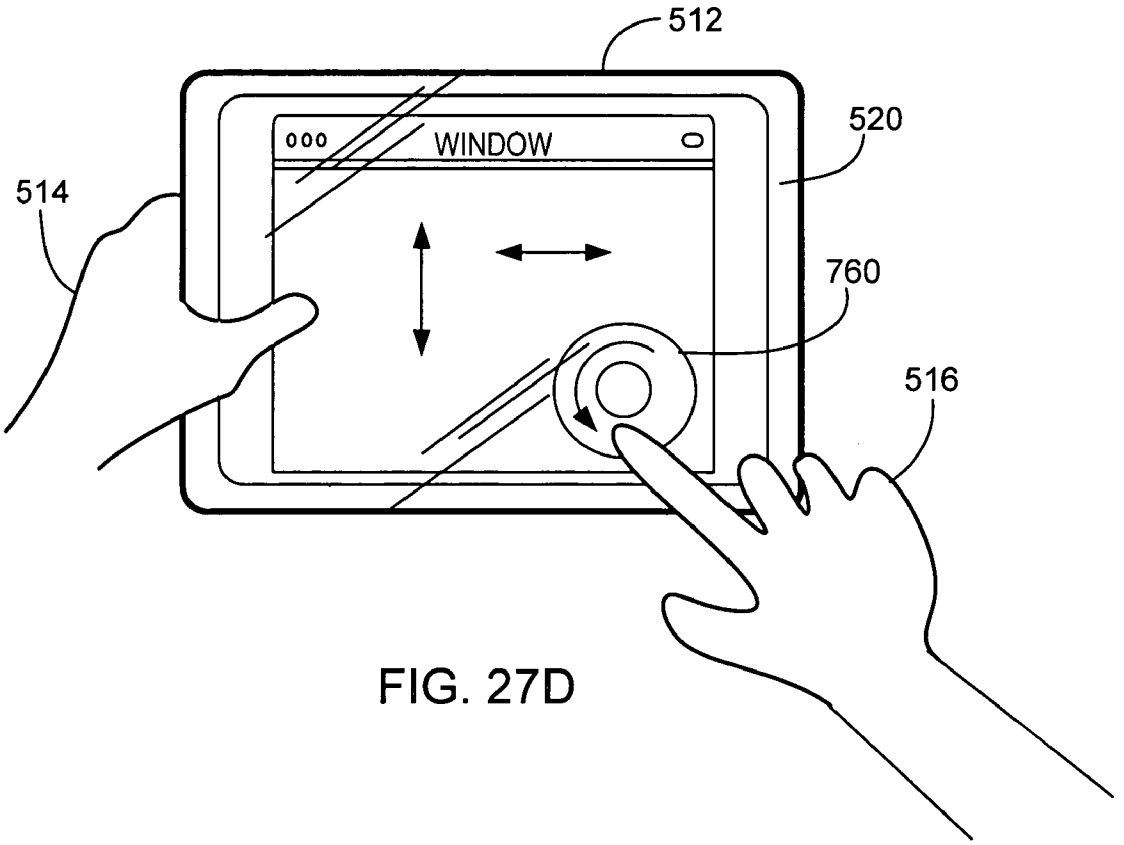


FIG. 27D

GESTURES FOR TOUCH SENSITIVE INPUT DEVICES

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to gesturing associated with touch sensitive devices.

[0003] 2. Description of the Related Art

[0004] 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.

[0005] 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.).

[0006] 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.

[0007] 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).

[0008] 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.

[0009] U.S. Pat. Nos. 5,612,719 and 5,590,219, assigned to Apple Computer, Inc. describe some other uses of gesturing. U.S. Pat. No. 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. Pat. No. 5,590,219 discloses a method for recognizing an ellipse-type gesture input on a display screen of a computer system.

[0010] 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.

[0011] Based on the above, there is a need for improvements in the way gestures are performed on touch sensitive devices.

SUMMARY OF THE INVENTION

[0012] The invention relates, in one embodiment, to a computer implemented method for processing touch inputs. The method includes reading data from a multipoint touch screen. The data pertains to touch input with respect to the touch screen. The method also includes identifying at least one multipoint gesture based on the data from the multipoint touch screen.

[0013] The invention relates, in another embodiment to a gestural method. The method includes detecting multiple touches at different points on a touch sensitive surface at the same time. The method also includes segregating the multiple touches into at least two separate gestural inputs occurring simultaneously. Each gestural input has a different function such as zooming, panning, rotating and the like.

[0014] The invention relates, in another embodiment to a gestural method. The method includes concurrently detecting a plurality of gestures that are concurrently performed with reference to a touch sensing device. The method also includes producing different commands for each of the gestures that have been detected.

[0015] The invention relates, in another embodiment to a gestural method. The method includes displaying a graphical image on a display screen. The method also includes detecting a plurality of touches at the same time on a touch sensitive device. The method further includes linking the detected multiple touches to the graphical image presented on the display screen.

[0016] The invention relates, in another embodiment to a method of invoking a user interface element on a display via a multipoint touch screen of a computing system. The method includes detecting and analyzing the simultaneous presence of two or more objects in contact with the multipoint touch screen. The method also includes selecting a user interface tool, from a plurality of available tools, to display on a display for interaction by a user of the computing system based at least in part the analyzing. The method further includes controlling the interface tool based at least in part on the further movement of the objects in relation to the multipoint touch screen.

[0017] The invention relates, in another embodiment, to a touch-based method. The method includes detecting a user

input that occurs over a multipoint sensing device. The user input includes one or more inputs. Each input has a unique identifier. The method also includes, during the user input, classifying the user input as a tracking or selecting input when the user input includes one unique identifier or a gesture input when the user input includes at least two unique identifiers. The method further includes performing tracking or selecting during the user input when the user input is classified as a tracking or selecting input. The method additionally includes performing one or more control actions during the user input when the user input is classified as a gesturing input. The control actions being based at least in part on changes that occur between the at least two unique identifiers.

[**0018**] The invention relates, in another embodiment, to a touch-based method. The method includes outputting a GUI on a display. The method also includes detecting a user input on a touch sensitive device. The method further includes analyzing the user input for characteristics indicative of tracking, selecting or a gesturing. The method additionally includes categorizing the user input as a tracking, selecting or gesturing input. The method further includes performing tracking or selecting in the GUI when the user input is categorized as a tracking or selecting input. Moreover, the method includes performing control actions in the GUI when the user input is categorized as a gesturing input, the actions being based on the particular gesturing input.

[**0019**] The invention relates, in another embodiment, to a touch-based method. The method includes capturing an initial touch image. The method also includes determining the touch mode based on the touch image. The method further includes capturing the next touch image. The method further includes determining if the touch mode changed between the initial and next touch images. The method additionally includes, if the touch mode changed, setting the next touch image as the initial touch image and determining the touch mode based on the new initial touch image. Moreover, the method includes, if the touch mode stayed the same, comparing the touch images and performing a control function based on the comparison.

[**0020**] The invention relates, in another embodiment, to a computer implemented method for processing touch inputs. The method includes reading data from a touch screen. The data pertaining to touch input with respect to the touch screen, and the touch screen having a multipoint capability. The method also includes converting the data to a collection of features. The method further includes classifying the features and grouping the features into one or more feature groups. The method additionally includes calculating key parameters of the feature groups and associating the feature groups to user interface elements on a display.

[**0021**] The invention relates, in another embodiment, to a computer implemented method. The method includes outputting a graphical image. The method also includes receiving a multitouch gesture input over the graphical image. The method further includes changing the graphical image based on and in unison with multitouch gesture input.

[**0022**] The invention relates, in another embodiment, to a touch based method. The method includes receiving a gestural input over a first region. The method also includes generating a first command when the gestural input is received over the first region. The method further includes receiving the same gestural input over a second region. The method additionally includes generating a second command when the same gestural input is received over the second region. The second command being different than the first command.

[**0023**] The invention relates, in another embodiment, to a method for recognizing multiple gesture inputs. The method includes receiving a multitouch gestural stroke on a touch sensitive surface. The multitouch gestural stroke maintaining continuous contact on the touch sensitive surface. The method also includes recognizing a first gesture input during the multitouch gestural stroke. The method further includes recognizing a second gesture input during the multitouch gestural stroke.

[**0024**] The invention relates, in another embodiment, to a computer implemented method. The method includes detecting a plurality of touches on a touch sensing device. The method also includes forming one or more touch groups with the plurality of touches. The method further includes monitoring the movement of and within each of the touch groups. The method additionally includes generating control signals when the touches within the touch groups are moved or when the touch groups are moved in their entirety.

[**0025**] It should be noted that in each of the embodiments described above, the methods may be implemented using a touch based input device such as a touch screen or touch pad, more particularly a multipoint touch based input device, and even more particularly a multipoint touch screen. It should also be noted that the gestures, gesture modes, gestural inputs, etc. may correspond to any of those described below in the detailed description. For example, the gestures may be associated with zooming, panning, scrolling, rotating, enlarging, floating controls, zooming targets, paging, inertia, keyboarding, wheeling, and/or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0026**] 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:

[**0027**] **FIG. 1** is a block diagram of a computer system, in accordance with one embodiment of the present invention.

[**0028**] **FIG. 2** is a multipoint processing method, in accordance with one embodiment of the present invention.

[**0029**] **FIGS. 3A** and B illustrate an image, in accordance with one embodiment of the present invention.

[**0030**] **FIG. 4** illustrates a group of features, in accordance with one embodiment of the present invention.

[**0031**] **FIG. 5** is a parameter calculation method, in accordance with one embodiment of the present invention.

[**0032**] **FIGS. 6A-6H** illustrate a rotate gesture, in accordance with one embodiment of the present invention.

[**0033**] **FIG. 7** is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

[**0034**] **FIG. 8** is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

[**0035**] **FIG. 9** is a diagram of a touch-based method, in accordance with one embodiment of the present invention.

[0036] **FIG. 10** is a diagram of a zoom gesture method, in accordance with one embodiment of the present invention.

[0037] **FIGS. 11A-11J** illustrates a zooming sequence, in accordance with one embodiment of the present invention.

[0038] **FIG. 12** is a diagram of a pan method, in accordance with one embodiment of the present invention.

[0039] **FIGS. 13A-13D** illustrate a panning sequence, in accordance with one embodiment of the present invention.

[0040] **FIG. 14** is a diagram of a rotate method, in accordance with one embodiment of the present invention.

[0041] **FIGS. 15A-15C** illustrate a rotating sequence, in accordance with one embodiment of the present invention.

[0042] **FIG. 16** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0043] **FIGS. 17A-17E** illustrate a floating control sequence, in accordance with one embodiment of the present invention.

[0044] **FIG. 18** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0045] **FIGS. 19A-19D** illustrate a zooming target sequence, in accordance with one embodiment of the present invention.

[0046] **FIG. 20** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0047] **FIGS. 21A-21E** illustrate a page turning sequence, in accordance with one embodiment of the present invention.

[0048] **FIG. 22** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0049] **FIGS. 23A-23D** illustrate an inertia sequence, in accordance with one embodiment of the present invention.

[0050] **FIG. 24** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0051] **FIGS. 25A-25D** illustrates a keyboard sequence, in accordance with one embodiment of the present invention.

[0052] **FIG. 26** is a diagram of a GUI operational method, in accordance with one embodiment of the present invention.

[0053] **FIGS. 27A-27D** illustrates a scroll wheel sequence, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0054] The invention generally pertains to gestures and methods of implementing gestures with touch sensitive devices. Examples of touch sensitive devices include touch screens and touch pads. One aspect of the invention relates to recognizing at least two simultaneously occurring gestures. Another aspect of the invention relates to displaying a graphical image and linking different touches that occur to the graphical image. Another aspect of the invention relates to immediately recognizing gestures so that actions associated with the gestures can be implemented at the same time. Another aspect of the invention relates to changing a displayed image based on and in unison with a gestural input, i.e., the displayed image continuously changes with changes in the gestural input such that the displayed image continuously follows the gestural input. Another aspect of the invention relates to implementing an input mode based on the number of fingers (or other object) in contact with the input device. Another aspect of the invention relates to providing region sensitivity where gestures mean different things when implemented over different areas of the input device. Another aspect of the invention relates to changing an input while making continuous contact with the touch sensitive surface of the touch sensitive device.

[0055] These and other aspects of the invention are discussed below with reference to **FIGS. 1-27**. 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.

[0056] **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.

[0057] 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.

[0058] 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.

[0059] 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.

[0060] 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**.

[0061] 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.

[0062] 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 Ser. No. 10/840,862, which is hereby incorporated herein by reference.

[0063] 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.

[0064] 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**.

[0065] 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.

[**0066**] 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.

[**0067**] 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.

[**0068**] 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.

[**0069**] 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**.

[**0070**] 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.

[**0071**] 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.

[**0072**] 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.

[**0073**] 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.

[0074] 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).

[0075] 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.

[0076] 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**.

[0077] **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 Ser. 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.

[0078] 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 **122**A is represented by ID_1, x_1, y_1, Z_1, θ_1, A_1 and the second feature **122**B 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.

[0079] The conversion from data or images to features may be accomplished using methods described in copending U.S. patent application Ser. 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).

[0080] 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.

[0081] 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.

[**0082**] 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 historesis 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.

[**0083**] 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.

[**0084**] **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.

[**0085**] 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.

[**0086**] To cite an example using the above methodologies, and referring to **FIGS. 6A-6H**, 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.

[**0087**] 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**.

[**0088**] 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.

[**0089**] 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**.

[0090] 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 **184**A associated with the knob **170** are grouped together to form group **188** and the feature **184**B associated with the thumb is filtered out. In alternative arrangements, the thumb feature **184**B 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).

[0091] 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.

[0092] 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.

[0093] 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.

[0094] 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.

[0095] 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.

[0096] **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.

[0097] 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.

[0098] **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.

[0099] **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.

[**0100**] 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.

[**0101**] 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.

[**0102**] **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.

[**0103**] 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.

[**0104**] **FIGS. 11A-11J** 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.

[**0105**] **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.

[**0106**] **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.

[**0107**] **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.

[**0108**] 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.

[**0109**] **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**.

[**0110**] 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.

[**0111**] **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.

[**0112**] 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.

[0113] 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.

[0114] **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.

[0115] **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.

[0116] **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.

[0117] **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.

[0118] **FIGS. 21A-21E** 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.

[**0119**] **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.

[**0120**] 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.

[**0121**] 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.

[**0122**] **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, Calif. 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.

[**0123**] 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.

[**0124**] 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.

[**0125**] **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.

[**0126**] 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.

[**0127**] 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.

[**0128**] 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.

[**0129**] **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 **576**A 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 **576**B on the shift key and another finger **576**A 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 **576**B from the shift key and places their finger **576**A over a desired letter (as indicated by the arrow).

[**0130**] **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 a first finger and more particularly, first and second fingers (to distinguish between tracking and gesturing) 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.). 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. In most cases, the set down of the fingers associate, link or lock the fingers (or finger) to the virtual scroll wheel when the fingers are positioned over the virtual scroll wheel. As a result, when the fingers are rotated, the rotate signal can be used to rotate the virtual scroll wheel in the direction of finger rotation (e.g., clockwise, counterclockwise). In most cases, the amount of wheel rotation varies according to the amount of finger rotation, i.e., if the fingers move 5 degrees then so will the wheel. Furthermore, the rotation typically occurs substantially simultaneously with the motion of the fingers. For instance, as the fingers rotate, the scroll wheel rotates with the fingers at the same time.

[**0131**] 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.

[**0132**] **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, Calif.), 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. 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.

[0133] It should be noted that although a surface scroll wheel is shown, the principals thereof can be applied to more conventional scroll wheels which are virtually based. For example, scroll wheels, whose axis is parallel to the display screen and which appear to protrude through the display screen as shown in **FIG. 28**. In this particular implementation, however, linear motion of the fingers are used to rotate the virtual scroll wheel.

[0134] The various aspects, embodiments, implementations or features of the invention can be used separately or in any combination.

[0135] 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.

[0136] 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.

1. A computer implemented method for processing touch inputs, said method comprising:

reading data from a touch screen, the data pertaining to touch input with respect to the touch screen, and the touch screen having a multipoint capability; and

identifying at least one multipoint gesture based on the data from the touch screen.

2. A computer implemented method as recited in claim 1 wherein said method further comprises:

performing a compounding operation associated with the at least one gesture.

3. A computer implemented method as recited in claim 1 wherein said method further comprises:

associating a user interface element to the at least one gesture.

4. A computer implemented method as recited in claim 3 wherein said method further comprises:

displaying the user interface element on the touch screen.

5. A computer implemented method as recited in claim 1 wherein said method further comprises:

displaying the user interface element on the touch screen prior to said reading; and

subsequently altering the user interface element being displayed based on the at least one gesture.

6. A computer implemented method as recited in claim 1 wherein said identifying identifies at least two multipoint gestures based on the data from the touch screen.

7. A computer implemented method as recited in claim 6 wherein the at least two gestures being identified are concurrently performed on the touch screen.

8. A computer implemented method as recited in claim 6 wherein the at least two gestures being identified are contiguously performed on the touch screen.

9. A gestural method, comprising:

detecting multiple touches at different points on a touch sensitive surface at the same time; and

segregating the multiple touches into at least two separate gestural inputs occurring simultaneously, each gestural input having a different function.

10. The gestural method as recited in claim 9 wherein touch sensitive surface is associated with a touch screen that overlays a display, and wherein the gestural inputs are selected from zooming, panning and rotating.

11. A gestural method, comprising:

concurrently detecting a plurality of gestures that are concurrently performed with reference to a touch sensing device;

producing different commands for each of the gestures that have been detected.

12. The method as recited in claim 11 wherein the plurality of gestures are implemented with the same group of touches.

13. The method as recited in claim 11 wherein the plurality of gestures are implemented with different groups of touches.

14. The method as recited in claim 11 wherein the gestures include rotate gestures, pang gestures, or zooming gestures.

15. A gestural method, comprising:

displaying a graphical image on a display screen;

detecting a plurality of touches at the same time on a touch sensitive device; and

linking the detected multiple touches to the graphical image presented on the display screen.

16. The method as recited in claim 15 wherein the graphical image is a user interface element.

17. The method as recited in claim 16 wherein the user interface element is displayed when a particular multitouch configuration is detected.

18. The method as recited in claim 17 wherein the user interface element is displayed in proximity to the multiple touches.

19. The method as recited in claim 18 wherein the user interface element is displayed underneath the multiple touches.

20. The method as recited in claim 16 wherein the multiple touches are detected over the displayed user interface element,

21. The method as recited in claim 16 wherein the multiple touches are associated with a single user interface element.

22. The method as recited in claim 16 wherein a first portion of the multiple touches are associated with a first user interface element and a second portion of the multiple touches are associated with a second user interface element that is different than the first user interface element.

23. The method as recited in claim 15 wherein after linking the detected multiple touches to the graphical image, the graphical image changes based on the motion of the linked multiple touches.

24. The method as recited in claim 23 wherein the graphical image is changed in unison with the motion of the linked multiple touches such that the changes in the graphical image continuously follows the motion of the linked multiple touches.

25. The method as recited in claim 23 wherein the size of the graphical image changes when at least one of the touches in the linked multiple touches is translated over the touch sensitive.

26. The method as recited in claim 23 wherein the size of features embedded in the graphical image changes when at least one of the touches in the linked multiple touches is translated over the touch sensitive surface.

27. The method as recited in claim 23 wherein the orientation of the graphical image changes when at least one of the touches in the linked multiple touches is rotated over the touch sensitive surface.

28. The method as recited in claim 23 wherein the position of the graphical image changes when the linked multiple touches are translated together over the touch sensitive surface.

29. A method of invoking a user interface element on a display via a multipoint touch screen of a computing system, said method comprising:

detecting and analyzing the simultaneous presence of two or more objects on contact with said touch screen;

based at least in part on said analyzing, selecting a user interface tool, from a plurality of available tools, to display on a display for interaction by a user of said computing system; and

controlling the interface tool based at least in part on the further movement of said objects in relation to said touch screen.

30. The method as recited in claim 29 wherein said selecting is also based in part on the current mode of the computing device at the time of the simultaneous presence of the two or more objects.

31. The method as recited in claim 29 wherein said tool is displayed at a location on the display proximate to the presence of said two or more objects.

32. A touch-based method, comprising

detecting a user input that occurs over a multipoint sensing device, the user input including one or more inputs, each input having a unique identifier;

during the user input, classifying the user input as a tacking or selecting input when the user input includes one unique identifier or a gesture input when the user input includes at least two unique identifiers;

performing tracking or selecting during the user input when the user input is classified as a tracking or selecting input;

performing one or more control actions during the user input when the user input is classified as a gesturing input.

33. The method as recited in claim 32 wherein scrolling or panning is performed when the at least two unique identifiers move together in substantially the same direction.

34. The method as recited in claim 32 wherein zooming is performed when the at least two unique identifiers linearly move away or towards one another.

35. The method as recited in claim 32 wherein rotation is performed when the at least two unique identifiers rotate relative to each other or relative to a known point.

36. The method as recited in claim 32 wherein multiple control actions are performed simultaneously during the same user input.

37. The method as recited in claim 32 wherein the user input is a continuous stroke, the stroke maintaining continuous contact on the multipoint sensing device.

38. A touch-based method, comprising:

outputting a GUI on a display;

detecting a user input on a touch sensitive device;

analyzing the user input for characteristics indicative of tracking, selecting or a gesturing;

categorizing the user input as a tracking, selecting or gesturing input;

performing tracking or selecting in the GUI when the user input is categorized as a tracking or selecting input;

performing control actions in the GUI when the user input is categorized as a gesturing input, the actions being based on the particular gesturing input.

39. A touch-based method, comprising:

capturing an initial touch image;

determining the touch mode based on the touch image;

capturing the next touch image;

determining if the touch mode changed between the initial and next touch images;

if the touch mode changed, setting the next touch image as the initial touch image and determining the touch mode based on the new initial touch image; and

if the touch mode stayed the same, comparing the touch images and performing a control function based on the comparison.

40. The method as recited in claim 39 wherein the control function is selected from tracking, panning, zooming, rotating, scrolling, or enlarging.

41. A computer implemented method for processing touch inputs, said method comprising:

reading data from a touch screen, the data pertaining to touch input with respect to the touch screen, and the touch screen having a multipoint capability;

converting the data to a collection of features;

classifying the features;

grouping the features into one or more feature groups;

calculating key parameters of the feature groups; and

associating the feature groups to user interface elements on a display.

42. The computer implemented method as recited in **41** wherein said method further comprises:

recognizing when at least one of the feature groups indicates performance of a gesture relative to its associated user interface element.

43. The computer implemented method as recited in **41** wherein said method further comprises:

providing user feedback when at least one of the feature groups indicates performance of a gesture relative to its associated user interface element.

44. The computer implemented method as recited in **41** wherein said method further comprises:

implementing an action when at least one of the feature groups indicates performance of a gesture relative to its associated user interface element.

45. The computer implemented method as recited in **44**, wherein said method further comprises:

providing user feedback in conjunction with the action.

46. The method as recited in claim 41 wherein the step of associating comprises:

receiving group of features;

determining if there is a change in number of features;

if there is a change, calculating initial parameter values;

if there is no change, calculating current parameter values; and

reporting both the initial and current parameter values.

47. A computer implemented method, comprising:

outputting a graphical image;

receiving a multitouch gesture input over the graphical image; and

changing the graphical image based on and in unison with multitouch gesture input.

48. The method as recited in claim 47 further comprising:

receiving a second multitouch gesture input over the graphical image; and

changing the graphical image based on and in unison with the second multitouch gesture.

49. The method as recited in claim 47 further comprising:

outputting a second graphical image:

receiving a second multitouch gesture input over the second graphical image; and

changing the second graphical image based on and in unison with the second multitouch gesture.

50. A touch based method, comprising:

receiving a gestural input over a first region;

generating a first command when the gestural input is received over the first region;

receiving the same gestural input over a second region; and

generating a second command when the same gestural input is received over the second region, the second command being different than the first command.

51. A method for recognizing multiple gesture inputs, the method comprising:

receiving a multitouch gestural stroke on a touch sensitive surface, the multitouch gestural stroke maintaining continuous contact on the touch sensitive surface;

recognizing a first gesture input during the multitouch gestural stroke; and

recognizing a second gesture input during the multitouch gestural stroke.

52. The method as recited in claim 51 further including recognizing a third gesture input during the multitouch gestural stroke

53. A computer implemented method, comprising:

detecting a plurality of touches on a touch sensing device;

forming one or more touch groups with the plurality of touches;

monitoring the movement of and within each of the touch groups; and

generating control signals when the touches within the touch groups are moved or when the touch groups are moved in their entirety.

54. A method for recognizing a zoom gesture made on a multipoint touch screen computing system, comprising:

detecting the relative locations of a first object and a second object at the same time;

detecting a change in the relative locations of said first and second object;

generating a zoom signal in response to said detected change.

55. The method as recited in claim 54 wherein said zoom signal is a zoom out signal.

56. The method as recited in claim 54 wherein said zoom signal is a zoom in signal.

57. The method as recited in claim 54 further comprising:

associating the first and second objects to an image on a GUI interface;

58. The method as recited in claim 54 further comprising zoom out the image when a zoom out signal is generated.

59. The method as recited in claim 54 further comprising zooming in the image when a zoom in signal is generated.

60. The method as recited in claim 54 further comprising zooming the image when a zoom signal is generated, and wherein the zooming occurs substantially simultaneously with the change in relative locations of the objects.

61. The method as recited in claim 61 wherein the amount of zooming varies according to the distance between the two objects.

62. A method for recognizing a pan gesture made on a multipoint touch screen, comprising:

detecting the presence of at least a first object and a second object at the same time;

monitoring the position of the said at least first and second objects when the objects are moved together across the touch screen; and

generating a pan signal when the position of the said at least first and second objects changes relative to an initial position.

63. The method as recited in claim 62 further comprising:

associating said at least first and second objects to an image on a GUI interface;

panning the image when a pan signal is generated; and

wherein the panning occurs substantially simultaneously with the motion of the objects.

64. A method for recognizing a rotate gesture made on a multipoint touch screen, comprising:

detecting the presence of at least a first object and a second object at the same time;

detecting a rotation of said at least first and second objects; and

generating a rotate signal in response to said detected rotation of said at least first and second objects.

65. The method as recited in claim 64 further comprising:

associating said at least first and second objects to an image on a GUI interface;

rotating the image when a rotate signal is generated; and

wherein the rotating occurs substantially simultaneously with the motion of the objects.

66. A computer implemented method for initiating floating controls via a touch screen, the method comprising:

detecting the presence of an object on the touch screen;

recognizing the object; and

generating a user interface element on the touch screen in the vicinity of the object based on the recognized object.

67. The method as recited in claim 66, wherein the user interface element includes one or more control options that can be selected by a user of the touch screen.

68. The method as recited in claim 67 further comprising generating a control signal when one of the control options is selected by the object.

69. The method as recited in claim 68 wherein the control signal modifies the functionality of the computer.

70. The method as recited in claim 68 wherein the control signal modifies a user interface element.

71. The method as recited in claim 66 wherein the object is a finger or a stylus.

72. A computer implemented method for initiating zooming targets via a touch screen, the method comprising:

displaying an image on a GU;

enlarging the image for a period of time when the presence of an object is detected over the image.

73. The method as recited in claim 72 wherein the image is a user interface element.

74. The method as recited in claim 73 wherein the user interface element is a control box containing one or more control buttons, and wherein said enlarging includes enlarging the control box and each of the control buttons.

75. The method as recited in claim 74 wherein the size of the control buttons correspond to the size of the object or larger so that the control buttons can be easily selected by the object.

76. The method as recited in claim 75 further comprising:

in the enlarged state, generating a control signal associated with the control button when the presence of the object is detected over one of the control buttons.

77. The method as recited in claim 72 wherein the object is a finger.

78. The method as recited in claim 72 further comprising:

implementing a gesture input when the presence of one or more objects are detected over portions of the GUI other than the image.

79. A computer implemented method of initiating a page turn via a touch screen, the method comprising:

displaying a page from a multitude of pages in a GUI presented on the touch screen;

detecting the presence of an object in a predetermined region on the touch screen over the page; and

generating a page turn signal when the object is translated on the touch screen in the predetermined region.

80. The computer implemented method as recited in claim 79 wherein the translation simulates a finger turning the page in a paper bound book.

81. The computer implemented method as recited in claim 79 wherein the translation pertains to a page turn gesture by a user.

82. The computer implemented method as recited in claim 79 wherein said method further comprises:

displaying a next page in response to the page tarn signal.

83. A computer implemented method of initiating inertia, the method comprising:

displaying an image on a GUI;

detecting a stroke on a touch sensitive surface;

noting the speed and direction of the stroke;

moving the image or features embedded in the image in accordance with the speed and direction of the stroke; and

slowing the motion of the image or features embedded in the image in accordance with inertia principals when the stroke is no longer detected.

84. The method as recited in claim 83 further comprising:

detecting an object on the touch sensitive surface when image or features embedded in the image is slowing down because of inertia;

stopping the motion of the image or features embedded in the image when another object is detected, the another object serving as a braking means to the moving image or features embedded in the image

85. A method of simulating a keyboard, comprising:

providing a display and a touch screen positioned over the display;

displaying a keyboard on the display, the keyboard including at least a first and a second key;

detecting the presence of a first object over the first key and a second object over the second key at the same time; and

generating a single control function in response to the detection of said first object over the first key and said second object over said second key.

86. The method as recited in claim 85 wherein the first and second objects are portions of one or more hands.

87. The method as recited in claim 85 wherein the first key is a modifying key that modifies the second key.

88. The method as recited in claim 87 wherein the first key is a shift key, control key or alt key.

89. 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.

90. The method as recited in claim 89 further comprising:

rotating the presented virtual wheel when the finger is moved about the virtual wheel.

91. The method as recited in claim 89 wherein the control signals implement scrolling on a display.

92. The method as recited in claim 32 wherein the control actions are based at least in part on changes that occur between the at least two unique identifiers.

93. The method as recited in claim 32 wherein the control actions are based at least in part on changes that occur with the at least two unique identifiers.

94. The method as recited in claim 38 wherein the gesturing input is two or more fingers that are translated together in substantially the same direction relative to the touch sensitive device, and wherein the control action is scrolling, the scrolling action being based on one or more characteristics of the translating two or more fingers.

95. The method as recited in claim 38 wherein the gesturing input is two or more fingers that are translated together in substantially the same direction relative to the touch sensitive device, and wherein the control action is panning, the panning action being based on one or more characteristics of the translating two or more fingers.

96. The method as recited in claim 38 wherein the user input is categorized as a tracking or selection input when only one finger is detected over touch sensitive device, and wherein the user input is categorized as a gesturing input when two or more fingers are detected over the touch sensitive device.

97. The method as recited in claim 96 wherein the control action corresponds to scrolling through the GUI when the gesturing input corresponds to two fingers translating together across the touch sensitive device.

98. The method as recited in claim 96 wherein the control action corresponds to panning through the GUI when the gesturing input corresponds to two fingers translating together across the touch sensitive device.

99. The method as recited in claim 96 wherein the control action corresponds to rotating the GUI or a GUI object when the gesturing input corresponds to two fingers rotating over the touch sensitive device.

100. The method as recited in claim 96 wherein the control action corresponds to zooming the GUI or a GUI object when the gesturing input corresponds to two fingers translating relative to each other over the touch sensitive device.

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