EXHIBIT 3.11

What is claimed is:

1. An object position detector, comprising:

a touch sensor formed as a substantially closed loop and having a physical constraint formed on an upper surface of said touch sensor and coextensive with said closed loop, said touch sensor configured to sense motion of an object proximate to said closed loop; and

a processor coupled to said touch sensor, said processor programmed to generate a signal in response to said motion on said touch sensor.

2. The object position detector of Claim 1, wherein said touch sensor is a capacitive touch sensor.

3. The object position detector of Claim 1, wherein said touch sensor is a resistive touch sensor.

4. The object position detector of Claim 1, wherein said touch sensor is an inductive sensor.

5. The object position detector of Claim 1, further comprising:

a processing unit;

instructions for directing said processing unit to:

receive information from said electrodes, and

generate an output responsive to receiving said information; and

a media readable by said processing unit that stores said instructions.

6. The object position detector of Claim 5, wherein said instructions further include instructions for directing said processing unit to detect an operating mode selected from activating an input device, tapping an activation zone, positioning an object in said activation zone, positioning an object in a navigation zone, activating a key on a keyboard and moving at least one object on said touch sensor responsive to receiving said information.

7. The object position detector of Claim 5, wherein said instructions for generating said output further comprise instructions for directing said processing unit to perform an action selected from controlling a cursor, scrolling through data, navigating a menu, adjusting a value setting control, selecting data, interfacing with a computer program, interfacing with a drawing program, changing a direction of motion, changing an axis of motion, changing a direction of value adjustment, and interfacing with a game program.

8. The object position detector of Claim 1, wherein said physical constraint is defined by at least one of the group consisting of a depression and a protrusion.

9. The object position detector of Claim 1, further comprising at least one activation

zone disposed proximate to said touch sensor and coupled to said processor.

10. The object position detector of Claim 7, wherein said at least one activation zone is demarked by a guide.

11. The object position detector of Claim 10, wherein said guide is said physical constraint.

12. The object position detector of Claim 1, further comprising a pointing input device disposed proximate to said touch sensor and coupled to said processor.

13. The object position detector of Claim 12, wherein said pointing input device is responsive to one of a position, a velocity, and a force of said object

14. The object position detector of Claim 1, further comprising an activation key disposed proximate to said touch sensor, wherein said activation key is configured to initiate an action in response to a user input.

15. The object position detector of Claim 1, wherein said closed loop is configured substantially into a shape selected from the group consisting of a circle, an oval, a triangle, a rectangle, a square, a figure-eight, a polygon, a convex polygon, a concave polygon, an ellipse, and a path that crosses itself.

16. The object position detector of Claim 1, wherein said processor generates a signal to cause a first action responsive to an object moving in a clockwise direction proximate to said closed loop.

17. The object position detector of Claim 16, wherein said processor generates a signal to cause a second action responsive to said object moving in a counter-clockwise direction proximate to said closed loop.

18. The object position detector of Claim 1, further comprising a starting position along said closed loop.

19. The object position detector of Claim 1, wherein the object position detector is disposed on a device selected from the group consisting of a computing device, a peripheral input device, a detachable input device, and a rotary control.

20. The object position detector of Claim 1, further comprising a switching method coupled to said object position detector that can be activated to select at least one mode.

21. The object position detector of Claim 20, wherein said switching method is selected from the group consisting of activating an input device, inputting in a zone, activating a key on a keyboard and moving at least one of said object on said closed loop.

22. The object position detector of Claim 20, wherein said mode is selected from the

group consisting of controlling a cursor, scrolling through data, navigating a menu, adjusting a value setting control, selecting data, interfacing with a computer program, interfacing with a drawing program, changing a direction of motion, changing an axis of motion, changing a direction of value adjustment, and interfacing with a game program.

23. The object position detector of Claim 1, further comprising at least one other touch sensor having a closed loop.

24. The object position detector of Claim 1, wherein an arrangement of electrodes of said touch sensor is interleaving.

25. The object position detector of Claim 1, wherein an arrangement of electrodes of said touch sensor is self-interpolating.

26. The object position detector of Claim 1, further comprising an electrode design that inherently outputs positional information in only one variable from said touch sensor.

27. The object position detector of Claim 1, further comprising an algorithm to calculate position on said touch sensor, said algorithm selected from the group consisting of a quadratic fitting algorithm, a centroid interpolation algorithm, a trigonometric weighting algorithm, and a quasi-trigonometric weighting algorithm.

28. The object position detector of Claim 1, further comprising at least two electrodes of said touch sensor electrically coupled to a single sensor input.

29. The object position detector of Claim 1, wherein said touch sensor is one-dimensional.

30. A solid-state object position detector, comprising:

a touch sensor having a plurality of electrodes disposed in a closed loop; and

a processor coupled to said touch sensor, said processor configured to output positional information in only one variable.

31. The solid-state object position detector of Claim 30, wherein said touch sensor is a capacitive touch sensor.

32. The solid-state object position detector of Claim 30, wherein said touch sensor is a resistive touch sensor.

33. The solid-state object position detector of Claim 30, wherein at least two of said electrodes are electrically coupled to a single sensor input.

34. The solid-state object position detector of Claim 30, further comprising:

a pointing input device disposed proximate to said touch sensor and coupled to said processor.

35. The solid-state object position detector of Claim 34, wherein said pointing input device is responsive to one of a position, a velocity, and a force of an input object.

36. The solid-state object position detector of Claim 30, wherein said processor is configured to operate in one of a first mode and a second mode, wherein said first mode reports relative motion and said second mode reports absolute position.

37. The solid-state object position detector of Claim 30, wherein at least two of said electrodes are interleaved.

38. The solid-state object position detector of Claim 37, wherein each of said at least two electrodes are in a shape of a lightning-bolt.

39. The solid-state object position detector of Claim 30, further comprising:

a guide disposed proximate to said electrodes.

40. The solid-state object position detector of Claim 39, wherein said guide is tactile.

41. The solid-state object position detector of Claim 30, wherein said processor is configured to receive positional information from said touch sensor in only one variable.

42. The solid-state object position detector of Claim 30, wherein said touch sensor is configured to output positional information from said closed loop in only one variable.

43. The solid-state object position detector of Claim 30, wherein said touch sensor is configured to output only positional information.

44. A touch sensor having a plurality of interleaving electrodes disposed in a closed loop, each of said electrodes is interdigitated with an adjacent neighboring one of said electrodes.

45. The touch sensor of Claim 44, wherein said electrodes are self-interpolating.

46. The touch sensor of Claim 44, wherein said touch sensor is a capacitive touch sensor.

47. The touch sensor of Claim 44, wherein at least two of said electrodes are electrically coupled to a single sensor input.

48. The touch sensor of Claim 44, wherein a layout of said electrodes is selected from the group consisting of a lighting-bolt design, a flower petal design, and a triangle design.

49. The touch sensor of Claim 44, wherein said electrodes are of about equal size.

50. The touch sensor of Claim 44, wherein more than one interdigitation occurs between each said neighboring said electrodes.

51. A touch sensor, comprising:

a plurality of sensor electrodes disposed in a closed loop; and

an indicator electrode disposed proximate to said sensor electrodes.

52. The touch sensor of Claim 51, wherein said touch sensor is a capacitive touch sensor.

53. The touch sensor of Claim 51, wherein said touch sensor is a resistive touch sensor.

54. The touch sensor of Claim 51, wherein at least two of said sensor electrodes are ohmically coupled together.

55. The touch sensor of Claim 51, wherein at least two of said sensor electrodes are interleaved.

56. The touch sensor of Claim 55, wherein each of said at least two sensor electrodes are in a shape of a lighting-bolt.

57. The touch sensor of Claim 51, further comprising:

a guide disposed proximate to said sensor electrodes.

58. The touch sensor of Claim 57, wherein said guide is tactile.

59. A solid-state object position detector, comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer such that $N \leq M$, each of said N sensor electrodes is coupled to a different one of said M sensor inputs;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of said touch sensor.

60. The solid-state object position detector of Claim 59, wherein said touch sensor is a capacitive touch sensor.

61. The solid-state object position detector of Claim 59, further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that $Q \leq M$, each of said Q sensing electrodes electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said object position detector.

62. The solid-state object position detector of Claim 59, wherein said processor is configured to operate in one of a first mode and a second mode, wherein said first mode reports relative motion and said second mode reports absolute position.

63. The solid-state object position detector of Claim 59, wherein at least two of said sensor electrodes are ohmically coupled together.

64. The solid-state object position detector of Claim 59, wherein at least two of said sensor electrodes are interleaved.

65. The solid-state object position detector of Claim 59, further comprising:

a guide disposed proximate to said sensor electrodes.

66. The solid-state object position detector of Claim 65, wherein said guide is tactile.

67. A solid-state object position detector, comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer;

wherein said N sensor electrodes are coupled to ones of said M sensor inputs such that at least two of said N sensor electrodes are coupled to a same one of said M sensor inputs;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of said touch sensor.

68. The solid state position detector of claim 67, further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that $Q \leq M$, each of said Q sensing electrodes electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said pointing input device.

69. A solid-state object position detector, comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

P touch sensors, where P is a positive integer, each of said P touch sensors having N sensor electrodes disposed in a closed loop, where N is a positive integer such that $N \leq (M / P)$, each of said N sensor electrodes of each of said P touch sensors is coupled to a different one of said M sensor inputs;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of each of said P touch sensors.

70. The solid state position detector of claim 69, further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that $Q \leq M$, each of said Q sensing electrodes electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said pointing input device.

71. The solid-state object position detector of Claim 69, wherein at least one of said

touch sensors is a capacitive touch sensor.

72. The solid-state object position detector of Claim 69, wherein at least two of said sensor electrodes are ohmically coupled together.

73. A solid-state object position detector, comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

P touch sensors, where P is a positive integer such that $P \leq M$, each of said P touch sensors having N sensor electrodes disposed in a closed loop, where N is a positive integer;

wherein said N sensor electrodes of each of said P touch sensors are coupled to said M sensor inputs such that at least two of said N sensor electrodes of each of said P touch sensors are coupled to a same one of said M sensor inputs;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of each of said P touch sensors.

74. The solid-state object position detector of claim 73, further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that $Q \leq M$, each of said Q sensing electrodes electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said pointing input device.

75. A combination comprising:

a processor having M sensor inputs, where M is a positive integer; and

an object position detector comprising:

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer such that $N \leq M$; and

an indicator electrode disposed proximate to said N sensor electrodes, each of said N sensor electrodes electrically coupled to a different one of M input electrodes;

wherein said indicator electrode is electrically coupled to at least one of said M sensor inputs that is not coupled to one of said N sensor electrodes; and

wherein said processor is configured to output data related to operation of said object position detector.

76. The combination of Claim 75, wherein said touch sensor is a capacitive touch sensor.

77. The combination of Claim 75, wherein said touch sensor is a resistive touch sensor.

78. The combination of Claim 75, further comprising:

a pointing input device disposed proximate to said touch sensor and in electrical communication with said processor.

79. The combination of Claim 75, wherein at least two of said sensor electrodes are ohmically coupled together.

80. The combination of Claim 75, wherein at least two of said sensor electrodes are interleaved.

81. The combination of Claim 80, wherein each of said at least two sensor electrodes are in a shape of a lighting-bolt.

82. A combination comprising:

a processor having M sensor inputs, where M is a positive integer; and

an object position detector comprising:

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer; and

an indicator electrode disposed proximate to said N sensor electrodes, said indicator electrode electrically coupled to at least one of said M sensor inputs that is not coupled to one of said N sensor electrodes;

wherein said N sensor electrodes are electrically coupled to ones of said M sensor inputs such that at least two of said N sensor electrodes are coupled to a same one of said M sensor inputs;

wherein said processor is configured to output data related to operation of said object position detector.

83. A combination comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

an object position detector comprising:

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer such that $N \leq M$; and

an indicator electrode disposed proximate to said N sensor electrodes, each of said N sensor electrodes electrically coupled to a different one of said M sensor inputs;

wherein said indicator electrode is electrically coupled to at least one of said M sensor inputs that is not coupled to one of said N sensor electrodes;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of said object position detector.

84. The combination of claim 83, further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that Q ≤ M, each of said Q sensing electrodes electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said pointing input device.

85. A combination comprising:

a processor having M sensor inputs, where M is a positive integer, said M sensor inputs having a primary function; and

an object position detector comprising:

a touch sensor having N sensor electrodes disposed in a closed loop, where N is a positive integer; and

an indicator electrode disposed proximate to said N sensor electrodes;

wherein said indicator electrode is electrically coupled to at least one of said M sensor inputs that is not coupled to one of said N sensor electrodes;

wherein said N sensor electrodes are electrically coupled to ones of said M sensor inputs such that at least two of said N sensor electrodes are coupled to a same one of said M sensor inputs;

wherein said processor is configured to output first data related to said primary function and to output second data related to operation of said object position detector.

86. The combination of claim 85 further comprising:

a pointing input device having Q sensing electrodes, where Q is a positive integer such that Q ≤ M, each of said Q sensing electrodes is electrically coupled to a different one of said M sensor inputs; and

wherein said primary function is related to operation of said pointing input device.

87. A method for processing signals from a plurality of electrodes in a closed loop sensor device comprising:

receiving a signal from each of said plurality of electrodes in said closed loop sensor;

determining a capacitance of each of said plurality of electrodes from said signals responsive to a receipt of said signal from each of said plurality of electrodes; and

determining position information of an input object proximate to said closed loop sensor responsive to a determination of said capacitance of each of said plurality of electrodes.

88. The method of claim 87 wherein said step of determining said position information comprises:

determining a highest capacitance electrode from said plurality of electrodes responsive to a determination of said capacitance of each of said plurality of electrodes;

determining an equation of an inverted parabola from said capacitance of said highest capacitance electrode, said capacitance of a first one of said plurality of electrodes on a first side of said highest capacitance electrode, and said capacitance of a second one of said plurality of electrodes on a second side of said highest capacitance electrode;

determining a center point of said inverted parabola from said equation responsive to a determination of said equation; and

determining said position information from said center point responsive to a determination of said center point.

89. The method of claim 88 wherein said step of determining said position information further comprises:

determining a modified center point by subtracting a modulus of a number of said plurality of electrodes from said center point of said inverted parabola responsive to a determination of said center point.

90. The method of claim 89 wherein said step of determining said position information further comprises:

applying a non-linear function to said modified center point to determine said position information responsive to a determination of said modified center point.

91. The method of claim 88 wherein said step of determining said position information further comprises:

applying a non-linear function to said center point to determine said position information responsive to a determination of said center point.

92. The method of claim 87 wherein said step of determining said position information comprises:

determining a highest capacitance electrode of said plurality of electrodes responsive to a determination of capacitance of each of said plurality of electrodes;

setting an orientation of said plurality of electrodes to have said highest capacitance electrode as a center of said plurality of electrodes;

determining a position of said input object by calculating a centroid responsive to said orientation of said plurality of electrodes being set; and

applying said reverse rotation function to said position to generate said position information.

93. The method of claim 92 wherein an application of said reverse rotation function sets said orientation of said plurality of electrodes to an original orientation.

94. The method of claim 87 wherein said step of determining said position information comprises:

applying a first periodic weighting function to capacitances of said plurality of said electrodes to determine a numerator,

applying a second periodic weighting function to said capacitances of said plurality of electrodes to determine a denominator , and

applying a third function to said numerator and said denominator to generate said position information responsive to a determination of said numerator and a determination of said denominator.

95. The method of claim 94 wherein said third function is a four quadrant arctangent.

96. The method of claim 94 wherein said step of applying said first periodic weighting function comprises:

applying a first periodic weighting function to said capacitance of each of said plurality of electrodes to determine a weighted capacitance component for each of said plurality of electrodes, and

determining a numerator from said weighted capacitance components of said plurality of electrodes responsive to a determination of said weighted capacitance component of each of said plurality of electrode.

97. The method of claim 96 wherein said first periodic weighting function is based on sine.

98. The method of claim 94 wherein said step of applying said second periodic weighting function to determine said denominator comprises:

applying said second periodic weighting function to said capacitance of each of said plurality of electrodes to determine a weighted capacitance component for each of said plurality of electrodes, and

determining a denominator from said weighted capacitance component of each of said plurality of electrodes responsive to a determination of said weighted capacitance component of each of said plurality of electrodes.

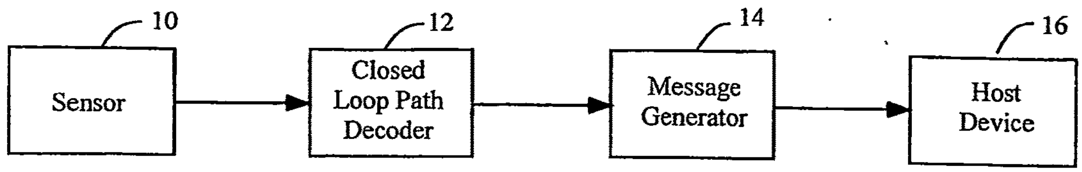


Fig. 1

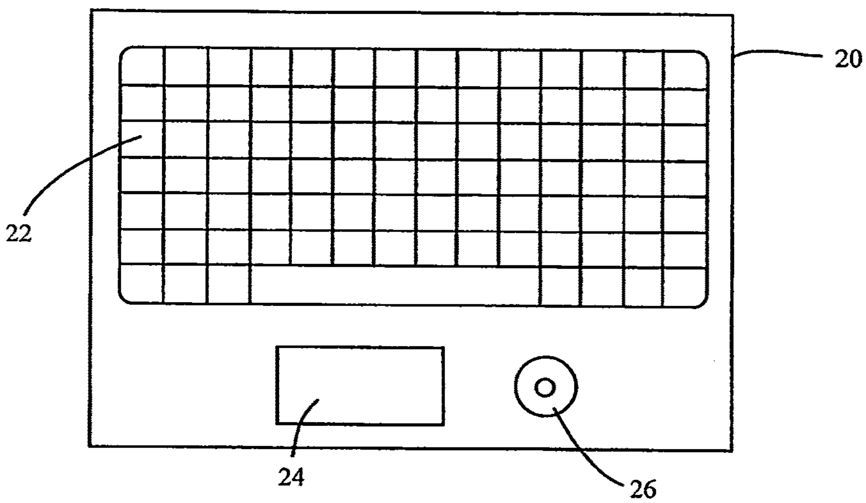


Fig. 2

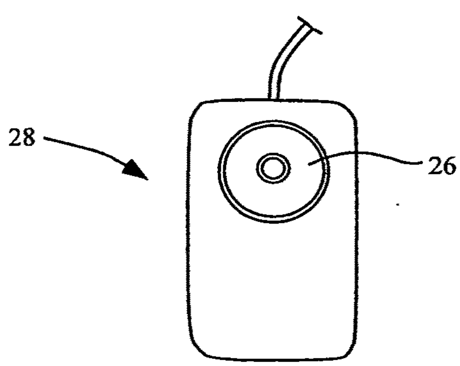


Fig. 3

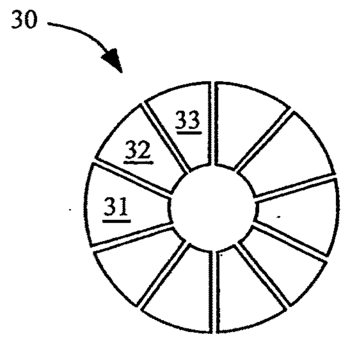


Fig. 4

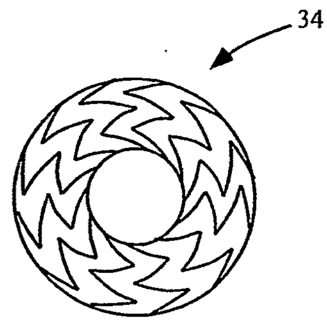


Fig. 5

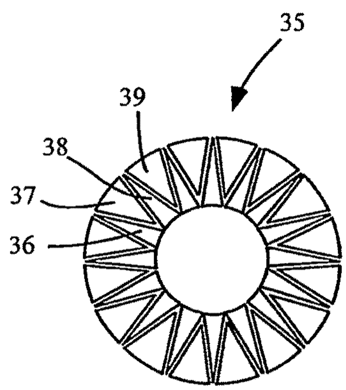


Fig. 6

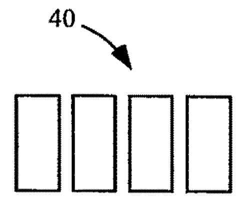


Fig. 7

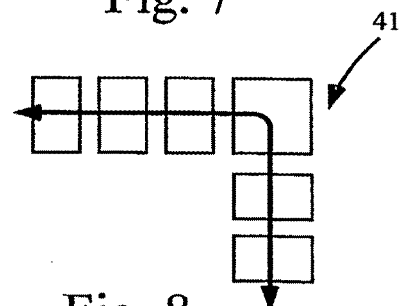


Fig. 8

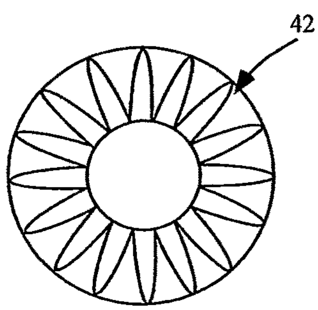


Fig. 9

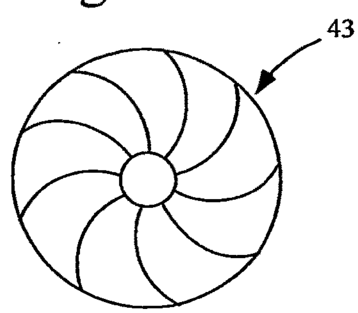


Fig. 10

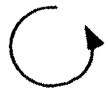


Fig. 11


Fig. 12

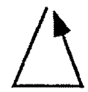


Fig. 13

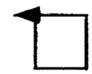


Fig. 14

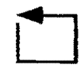


Fig. 15


Fig. 16


Fig. 17

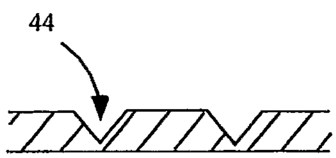


Fig. 18

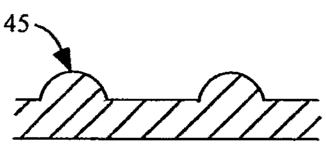


Fig. 19

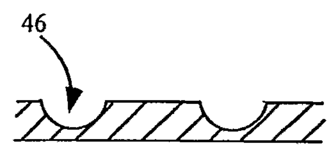


Fig. 20

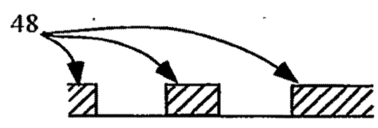


Fig. 21

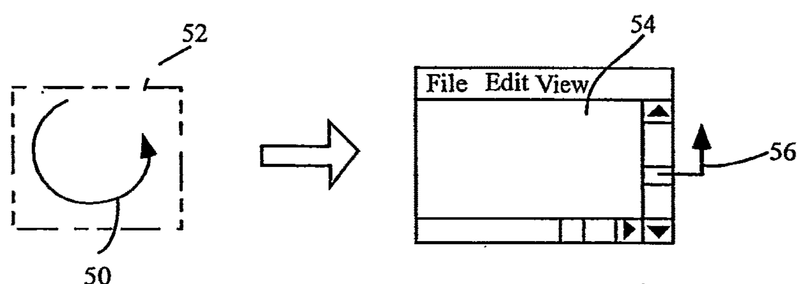
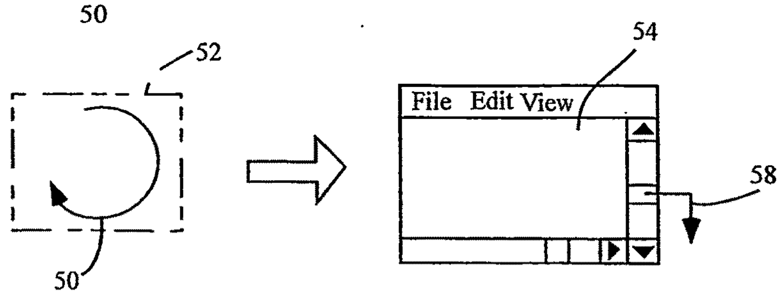
Fig. 22


Fig. 23


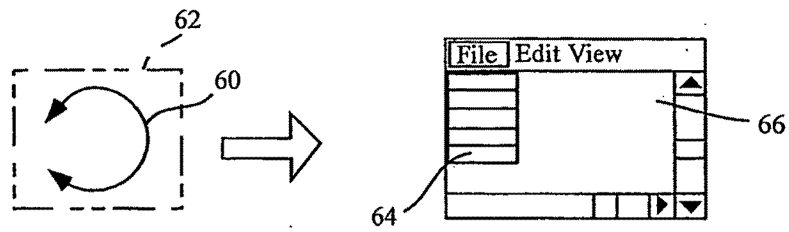


Fig. 24

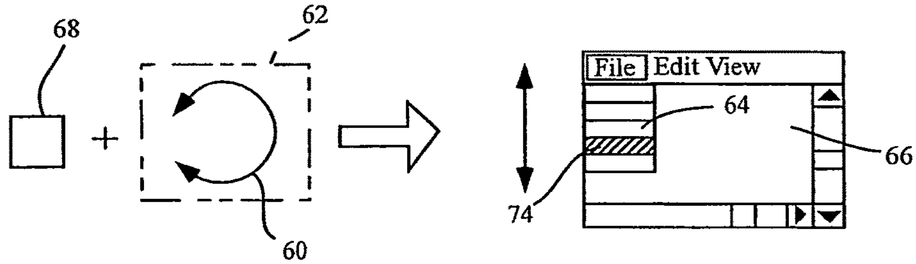


Fig. 25

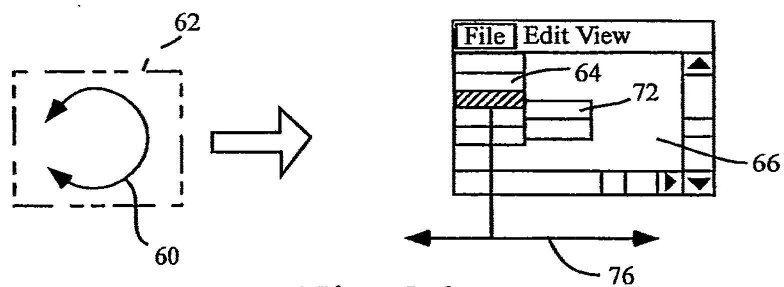


Fig. 26

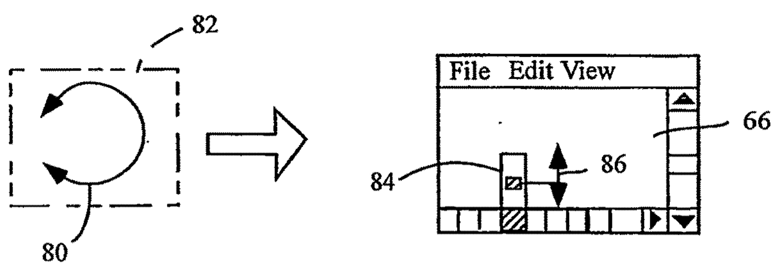


Fig.27

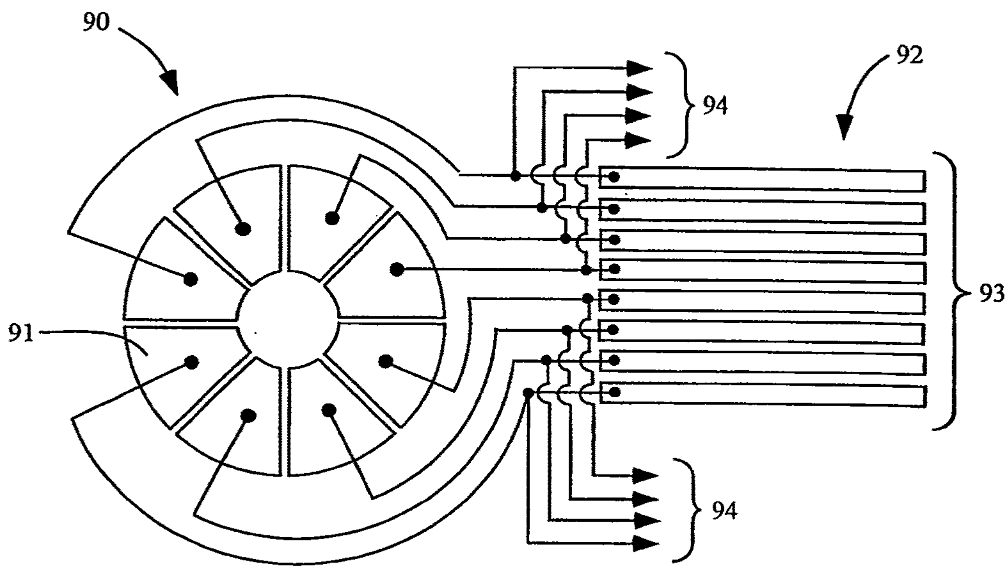


Fig. 28

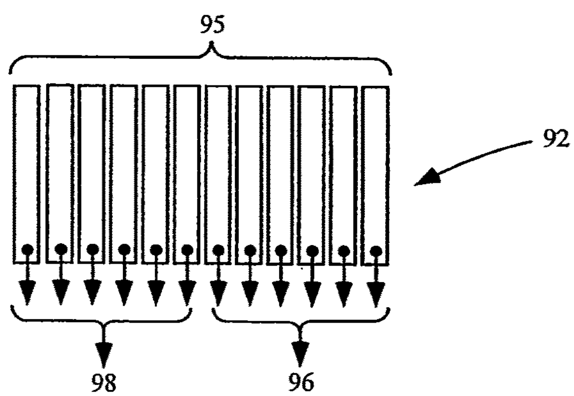


Fig. 29

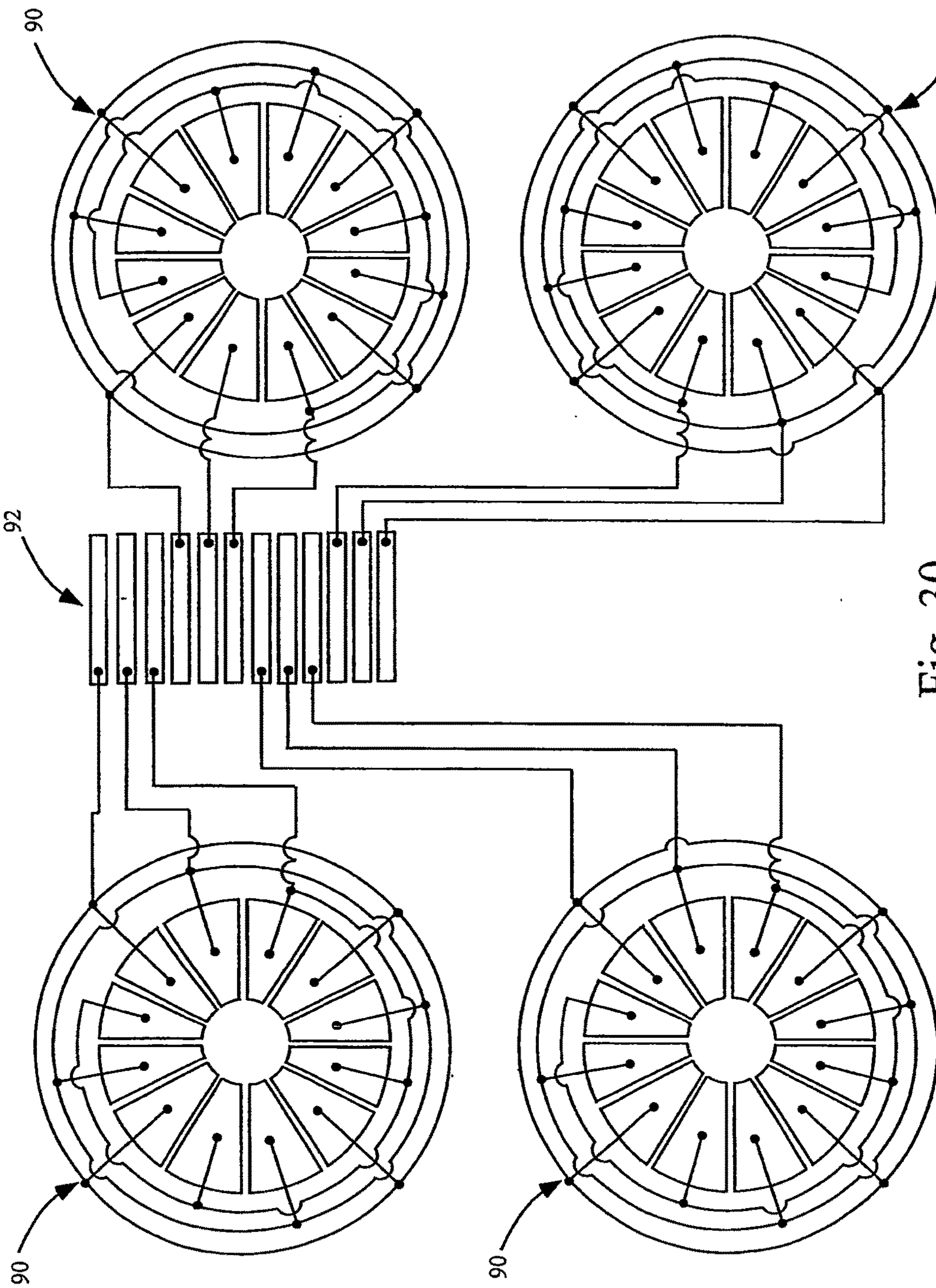


Fig. 30

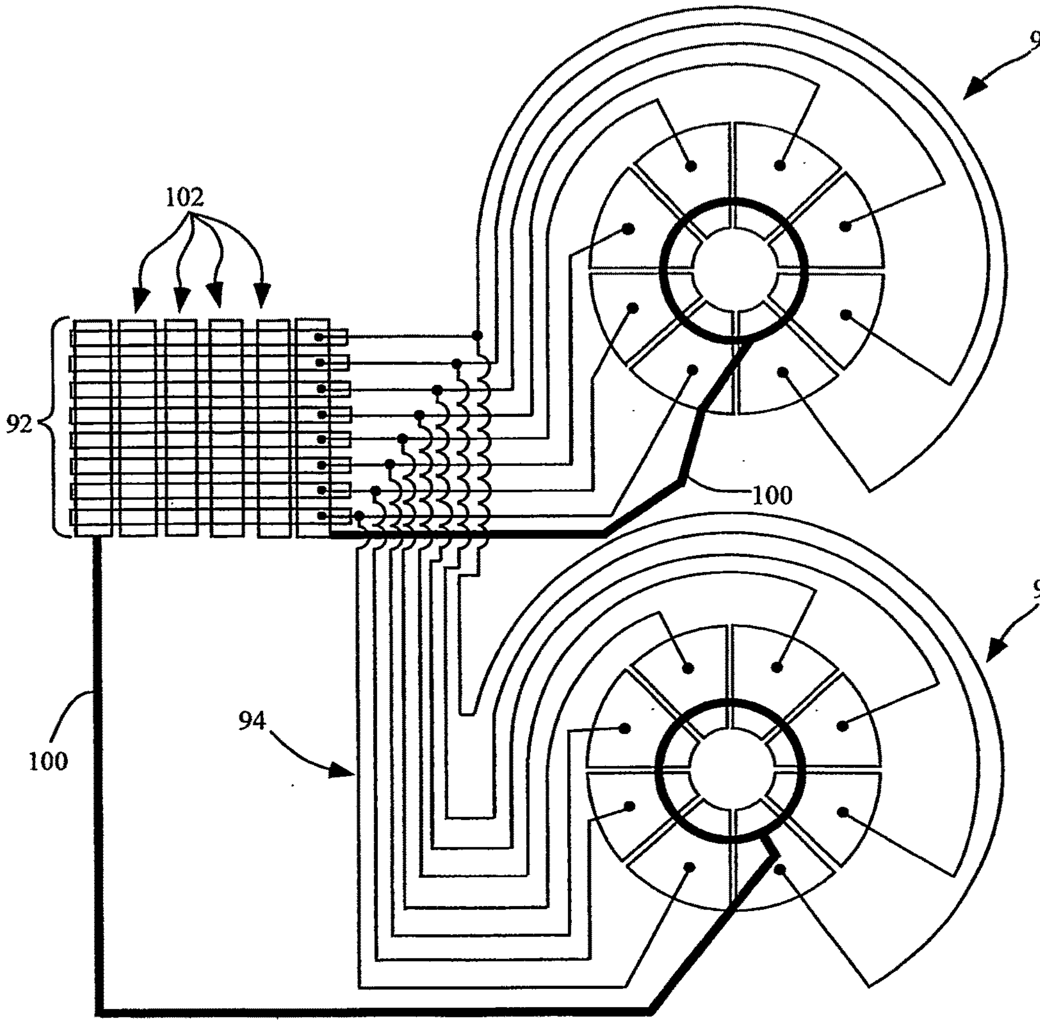


Fig. 31

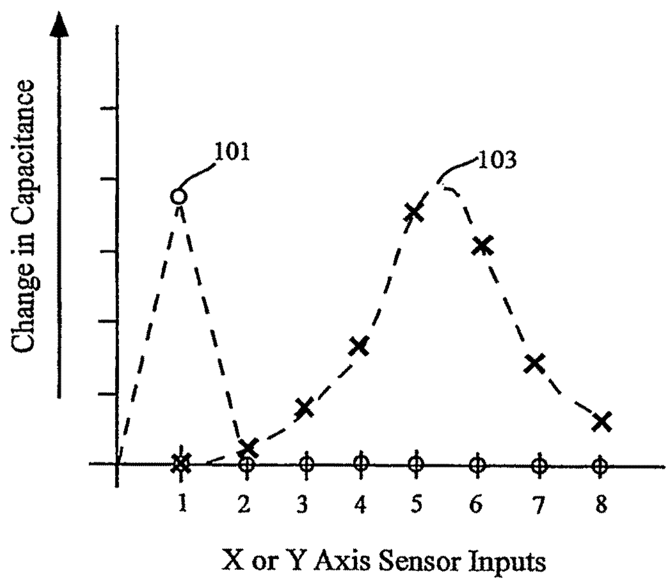

Change in Capacitance
101
103
1
2
3
4
5
6
7
8
X or Y Axis Sensor Inputs

Fig. 32

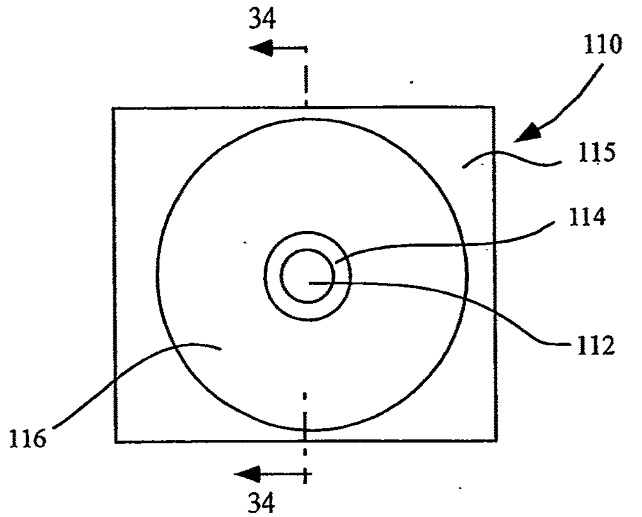


Fig. 33

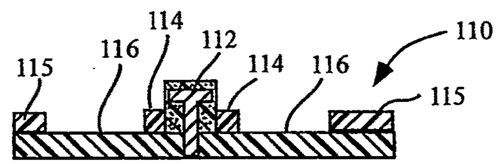


Fig. 34

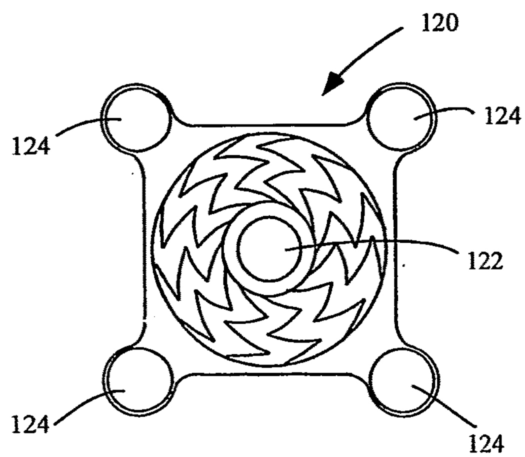


Fig. 35

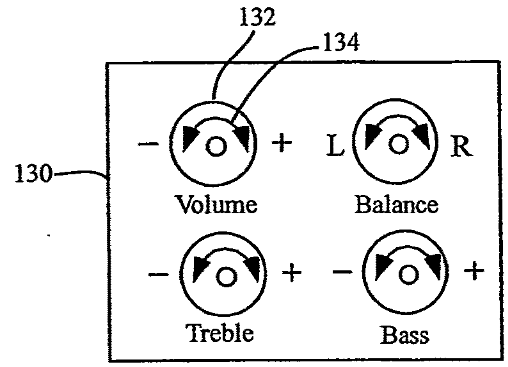

132
134
130
− +
L R
Volume
Balance
− +
− +
Treble
Bass

Fig. 36

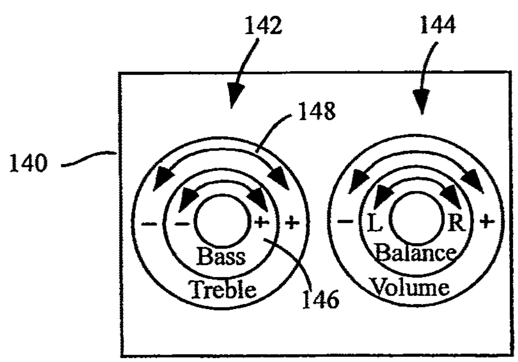

142
144
148
140
− − + +
− L R +
Bass
Treble
146
Balance
Volume

Fig. 37

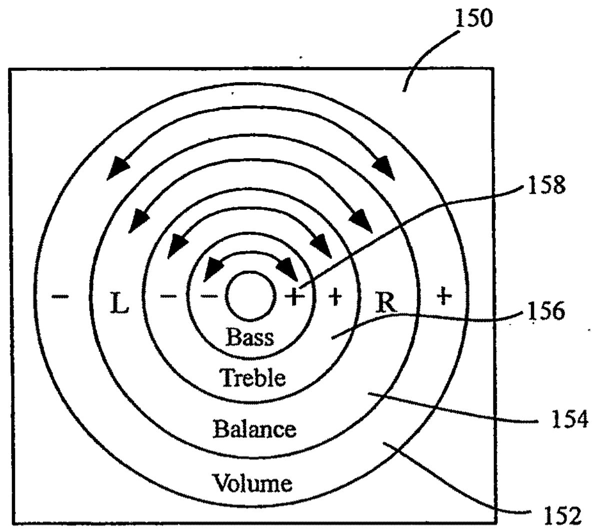

150
158
156
154
152
- L - - + + R +
Bass
Treble
Balance
Volume

Fig. 38

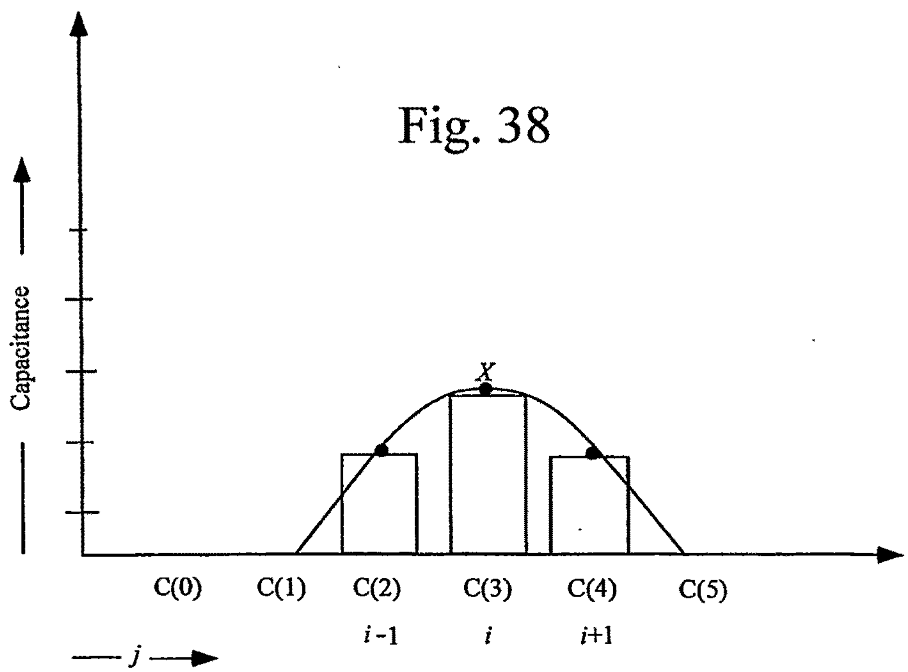

Capacitance
X
C(0) C(1) C(2) C(3) C(4) C(5)
i -1 i i+1
j

Fig. 40

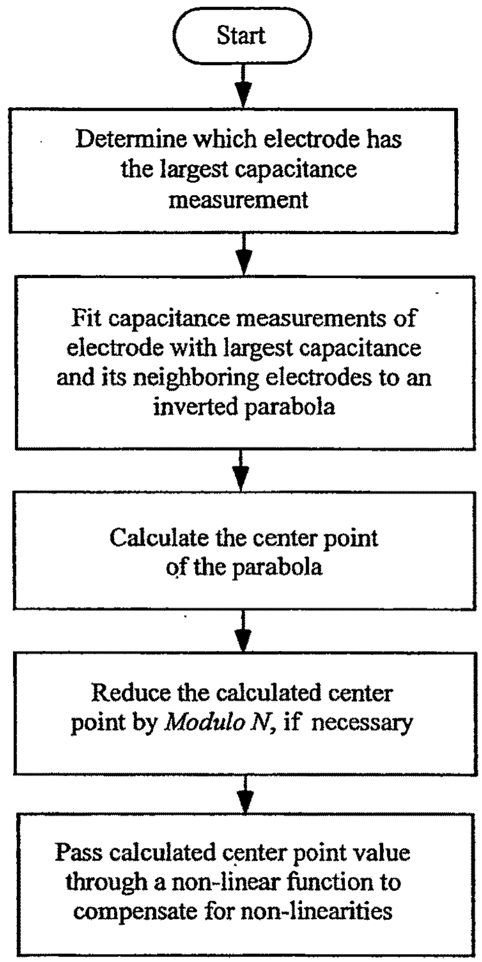

Start
Determine which electrode has the largest capacitance measurement
Fit capacitance measurements of electrode with largest capacitance and its neighboring electrodes to an inverted parabola
Calculate the center point of the parabola
Reduce the calculated center point by *Modulo N*, if necessary
Pass calculated center point value through a non-linear function to compensate for non-linearities

Fig. 39

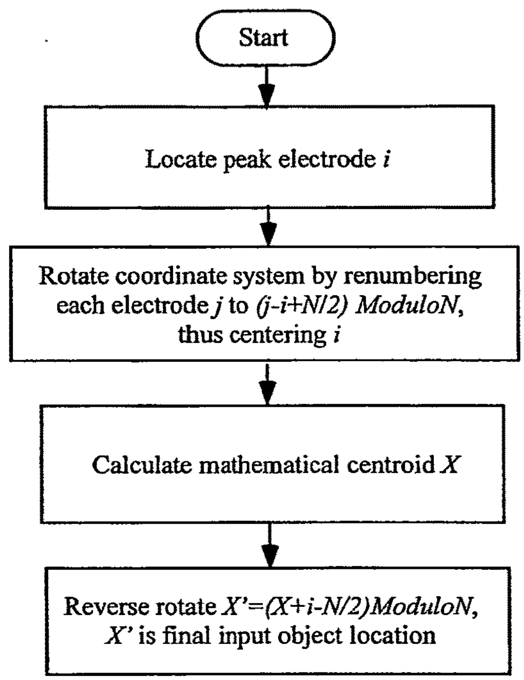

Start
Locate peak electrode *i*
Rotate coordinate system by renumbering each electrode *j* to *(j-i+N/2) ModuloN*, thus centering *i*
Calculate mathematical centroid *X*
Reverse rotate *X'=(X+i-N/2)ModuloN*, *X'* is final input object location

Fig. 41

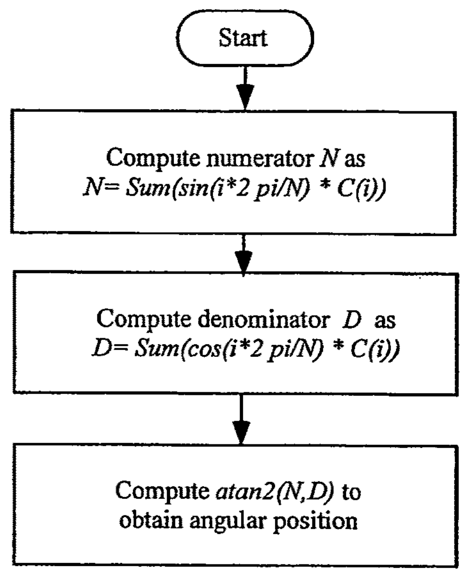

Start
Compute numerator *N* as
*N= Sum(sin(i*2 pi/N) * C(i))*
Compute denominator *D* as
*D= Sum(cos(i*2 pi/N) * C(i))*
Compute *atan2(N,D)* to
obtain angular position

Fig. 42

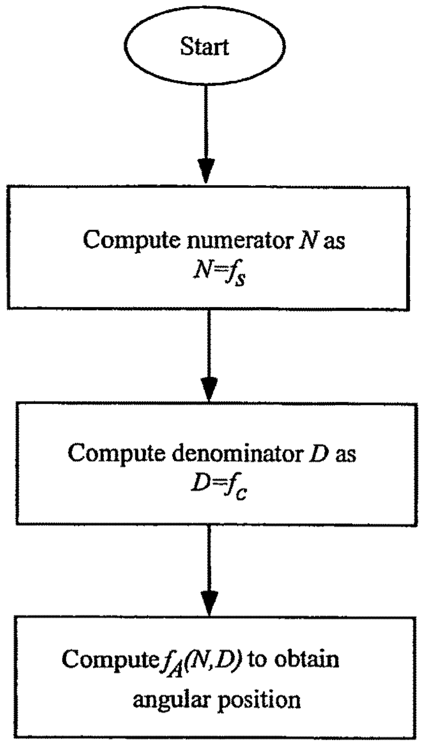

Start
Compute numerator N as $N=f_s$
Compute denominator D as $D=f_c$
Compute $f_A(N,D)$ to obtain angular position

Fig. 43

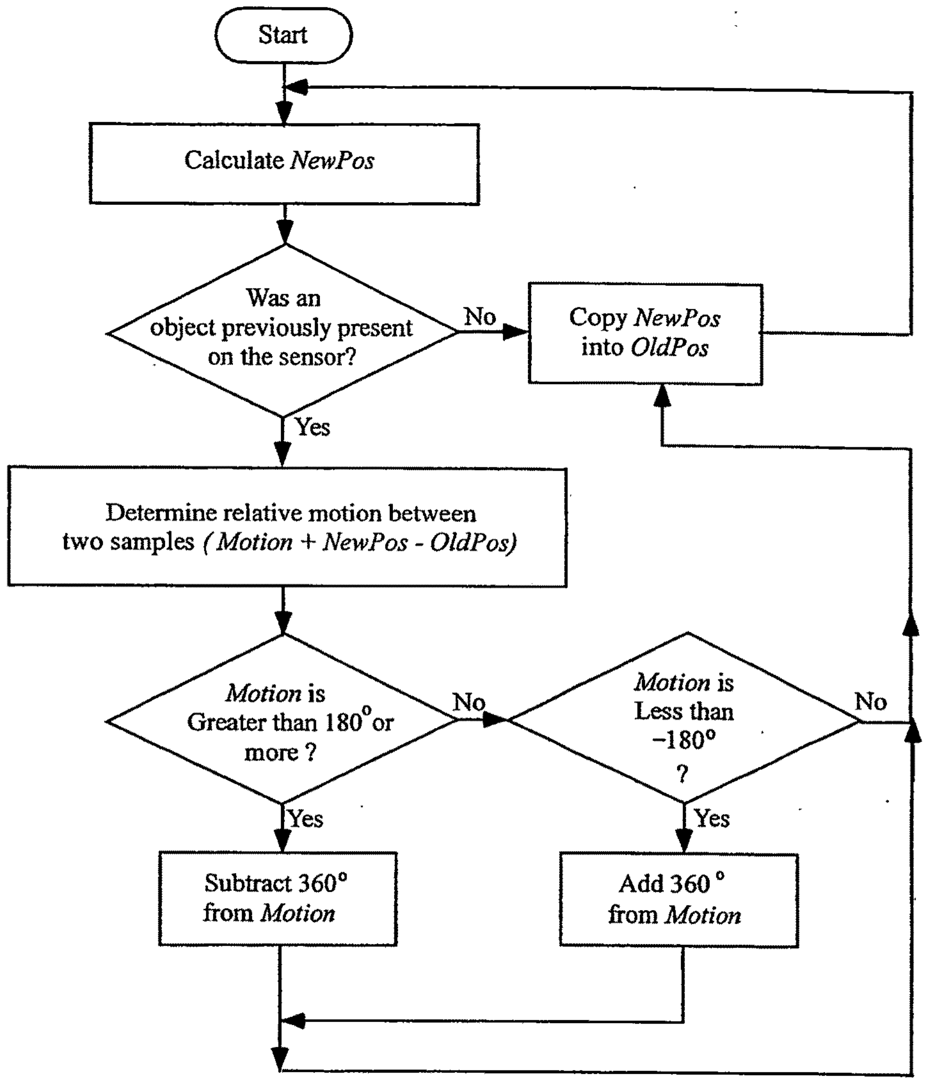

Start
Calculate *NewPos*
Was an object previously present on the sensor?
No
Copy *NewPos* into *OldPos*
Yes
Determine relative motion between two samples (*Motion* + *NewPos* - *OldPos*)
Motion is Greater than 180° or more ?
No
Motion is Less than −180° ?
No
Yes
Subtract 360° from *Motion*
Yes
Add 360 ° from *Motion*

Fig.44

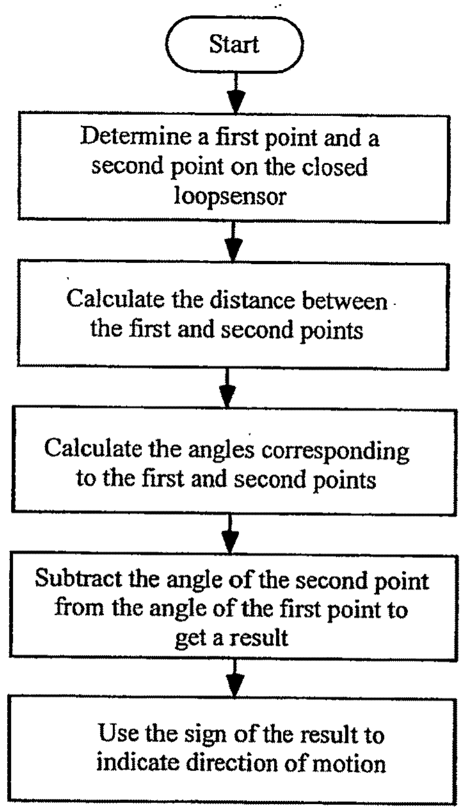

Start
Determine a first point and a second point on the closed loopsensor
Calculate the distance between the first and second points
Calculate the angles corresponding to the first and second points
Subtract the angle of the second point from the angle of the first point to get a result
Use the sign of the result to indicate direction of motion

Fig. 45

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/11015

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G08C 21/00; G09G 3/02
US CL : 178/18.01,18.05,18.06,18.07,31,32; 345/173
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 178/18.01,18.05,18.06,18.07,31,32; 345/173

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,159,159 A (ASHER) 27 OCTOBER 1992, (figs.1-5,7-9); col. 3, 55- col. 4, lines 52.	1-58
Y	US 5,518,078 A (TSUJIOKA et al) 21 MAY 1996, All	1-58
X ---- Y	US 5,907,472 A (FARAHMANDI et al) 25 May 1999 (see, Abstract and fig. 9A)	1-58 ------ 44-50

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
01 AUGUST 2003	21 AUG 2003

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	AMARE MENGIST Telephone No. (703) 305-3880

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G06F 3/14, 15/02	A2	(11) International Publication Number: **WO 98/14863** (43) International Publication Date: 9 April 1998 (09.04.98)

(21) International Application Number: PCT/IB97/01139

(22) International Filing Date: 22 September 1997 (22.09.97)

(30) Priority Data:
9620464.9 1 October 1996 (01.10.96) GB

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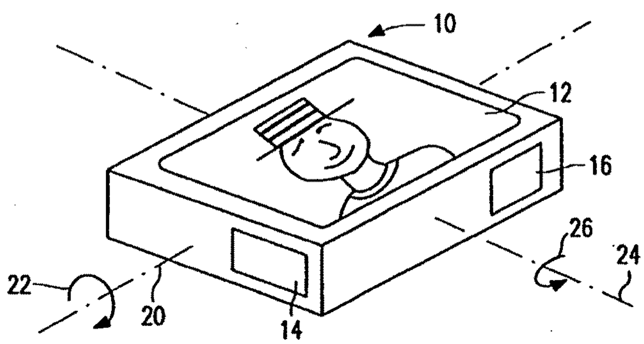
(81) Designated States: JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

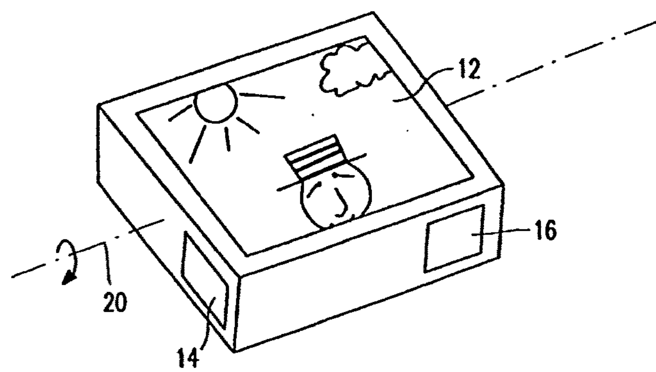
(54) Title: HAND-HELD IMAGE DISPLAY DEVICE

(57) Abstract

A hand-held image display device (10) has a display (12) and at least one sensor (14, 16) responsive to an angle of tilt of the device (10). The tilt of the device is used to effect a scrolling function of the display (12).



A



B

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HAND HELD IMAGE DISPLAY DEVICE

This invention relates to a hand held image display device, such as a hand held computer or electronic diary.

It is known for conventional image display devices to include a scrolling function which enables the display device to show only a portion of an image to be viewed. This enables a magnification to be selected of the displayed portion for comfortable viewing, and the scroll function enables easy viewing of the entire image to be displayed. Conventionally, the scroll function may be implemented as horizontal and/or vertical scroll bars which may be activated using an electronic pointing device such as a mouse. Alternatively, a keyboard may be used to scroll up and down a document, or indeed from side to side.

In the case of a hand held device, additional keys may be required to enable this function to be implemented using a keyboard input, and the use of a mouse may not be possible.

According to the invention there is provided a hand held image display device having an image display means and at least one sensor which is responsive to an angle of inclination of the device, wherein the display means displays a portion of an image to be displayed, and the selection of the portion to be displayed is controlled in dependence upon the sensor signal, such that the portion to be displayed is controllable by varying the angle of inclination of the device.

In the device according to the invention, a portion of an image to be displayed is selected by tilting the device itself. This provides a natural operation for scrolling around text documents or images.

Preferably the angle of inclination comprises the angle to the horizontal of a first axis extending from the top to the bottom of the display means. In other words, it is possible to scroll up and down a document by pivoting the device about a horizontal axis extending laterally across the screen.

Similarly, the angle of inclination may comprise the angle to the horizontal of a second axis extending from one side to the other side of the display means. In this case, it is possible to scroll from side to side of a document by tilting the device left or right about an axis extending from the top to the bottom of the screen.

By using either or both of these possibilities, the impression is generated that the document displayed by the device can be rolled about within the screen until the desired portion of the image is displayed.

The sensor or sensors may comprise tilt switches so that a predetermined deviation from the horizontal gives rise to the scrolling effect. However, it is preferred that the sensor or sensors comprise force transducers which provide a variable signal depending upon the level of inclination of the device. In this way, it is possible to put into effect a control of the speed of scrolling as well as the direction.

Preferably, the device further comprises calibration means for defining a reference inclination of the device, such that at the reference inclination of the device, the portion to be displayed is constant. In this way, it is possible to ensure that the user can select a preferred operating position of the device for which the image to be displayed remains constant. Deviation from this preferred orientation of the device gives rise to the required scrolling.

The image display device may comprise a hand held data processing device, such as a telephone, personal digital organiser or game module.

The present invention will now be described by way of example, with reference to and as shown in the accompanying drawings in which:

Figure 1 shows in simplified form a device according to the invention for showing the operating principle; and

Figure 2 shows a data processing device employing a display of the present invention.

Figure 1 part A shows a hand held image display device 10 according to the invention and including a display screen 12 for displaying at least a portion of an image to be displayed. The device 10 includes at least one tilt sensor, and two such sensors 14, 16 are shown in Figure 1, arranged orthogonally. The sensors 14, 16 each enable an angle of inclination of the device 10 to be determined which is subsequently used to control a display command which effects scrolling of the image display.

When a programme produces a quantity of data for display which is greater than can be displayed at any one time on a display device, it is conventional for a scrolling function to be provided. For example, in the case of word processing software package, horizontal and vertical scrolls may be provided enabling a user to move between portions of a document whilst maintaining sufficient clarity or size in the portion of the document displayed. The scrolling function either requires the use of a mouse, to operate on scroll bars, or requires the use of direction indicators on a keyboard.

The invention provides a more intuitive approach for image scrolling on the screen of a hand held device, wherein the whole device is tipped. For example, if the device is tipped towards the bottom of the screen the image or text displayed by the screen will "fall" down the screen. If the device is tipped towards the top of the screen, the image or text displayed will "fall" up.

As shown in Figure 1, two sensors 14, 16 may be provided, each of which is responsive to tilting of the device about a horizontal axis.

Taking the sensor 14, an axis of the sensor extends along a top-to-bottom direction of the display 12, and is therefore responsive to tilting of the device 10 about a horizontal axis 20 which extends across the display 12. Thus, the sensor 14 is responsive to rotation as represented by arrow 22 in Figure 1 part A. The sensor 14 provides the most intuitive feel for scrolling up and down a document. As shown in Figure 1 part B, when the base of the screen 12 is pivoted downwardly about the axis 20 the image displayed by the screen 12 effectively falls down as shown. In the case of a text document, the display scrolls towards the beginning of the document.

Figure 1 also represents a second sensor 16 which has an axis extending from side to side of the display 12 and is therefore responsive to rotation of the device 10 about a horizontal axis 24 extending from the top to the bottom of the display 12. Thus, the sensor 16 is responsive to pivoting about the axis 24 as represented by arrow 26. This enables scrolling from side to side of an image displayed on the screen 12, for example where the width of an image to be displayed is greater than the width which can be displayed on the display screen at any one time.

In order to implement the invention, the controller which determines the information to be displayed must receive signals form the sensors 14, 16. The sensors may comprise conventional tilt switches which are binary devices detecting when the angle of tilt from a horizontal plane (in two directions) is greater than a predetermined level. The use of such sensors may provide limited control capability for the scroll function, since it is not possible to determine the speed at which the user wishes to scroll around the image. Of course, the use of different tilt switches each with differing sensitivity may provide a number of levels of control for the display, but the use of analogue tilt sensors is preferred. Such analogue sensors will enable proportional control to be possible, and may comprise arrangements of pressure sensors which detect the pull of gravity.

One example of such a sensor is made by the company "Analogue Devices" under the code ADXL05. This is a monolithic silicon device known as a "single chip accelerometer" having an etched substrate which deflects under the influence of gravity. This deflection alters a capacitance which is measured, and enables a steady state resolution of 0.005g.

The use of proportional tilt sensors may also enable a reference orientation of the device 10 to be established for which the displayed information is stationary, and this reference orientation need not necessarily be horizontal. It is possible, through appropriate software, to put into effect a dead zone comprising a range of orientations in which the displayed information remains constant. These orientations will then cover the normal operating position of the device by a user. Of course, if may be preferred that each user can reset the dead zone according to the situation in which the device is being used. For example, the device may be rested on a horizontal work surface in which case the dead zone will operate when the device is in a substantially horizontal plane. Alternatively, if a user is standing while operating the device, the hand held device may be held in a nearly upright position, for example in the case of a mobile phone when the user may be scrolling between stored telephone numbers. It will be apparent to those skilled in the art that each of these commands may easily be implemented with appropriate software.

It would, of course, also be desirable to include an override function so that any unwanted scrolling may be prevented, for example, for situations when the device will not be stationary during use.

Those skilled in the art will appreciate that various software tools may be employed to improve the interface between the device 10 and the user. For example, a portion of a complete image can be displayed with the desired scale, and information may be provided around the edge of the display screen 12 which indicates to what extent the entire image extends, for example by showing a compressed version of the remainder of the image. Equally, scroll bars may be employed as position indicators , as are conventionally used in word processing packages.

The technique described with reference to Figure 1 may be applied to many different types of hand held device where there is a large amount of information to be displayed. For example, the device may comprise a personal organiser, such as represented in Figure 2, a communications device such as a pager or mobile phone or any number of other such products.

In Figure 2, the device 10 comprises a personal organiser and the display screen 12 includes scroll bars 30 representing the position of the portion displayed within the entire list of information. The specific hardware and software required to implement the invention will be appreciated by those skilled in the art. Generally speaking, the tilt sensors 14, 16 will provide input signals to a microprocessor which controls a display controller. The information to be displayed will then be modified in dependence upon the sensor signals by appropriate software implementation. The software will then enable the calibration stage referred to earlier (for providing a dead zone) to be put into effect as well as any override function which may be provided. Implementation of the invention may be carried out using conventional apparatus, which will therefore not be described in detail in the present application.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design and use of electrical or electronic circuits and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation of one or more of those features which would be obvious to persons skilled in the art, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

CLAIMS

1. A hand-held image display device having an image display means and at least one sensor which is responsive to an angle of inclination of the device, wherein the display means displays a portion of an image to be displayed, and the selection of the portion to be displayed is controlled in dependence upon the sensor signal, such that the portion to be displayed is controllable by varying the angle of inclination of the device.

2. A hand-held image display device as claimed in claim 1, wherein the angle of inclination comprises the angle to the horizontal of a first axis extending from the top to the bottom of the display means.

3. A hand-held image display device as claimed in claim 1, wherein the angle of inclination comprises the angle to the horizontal of a second axis extending from one side to the other side of the display means.

4. A hand-held image display device as claimed in claim 1, comprising two sensors, one of which is responsive to the angle to the horizontal of a first axis extending from the top to the bottom of the display means, and the other of which is responsive to the angle to the horizontal of a second axis extending from one side to the other side of the display means.

5. A hand-held image display device as claimed in any preceding claim, wherein the sensor or sensors comprise tilt switches.

6. A hand-held image display device as claimed in any one of claims 1 to 4, wherein the sensor or sensors comprise force transducers which provide a variable signal depending upon the level of inclination of the device.

7. A hand-held image display device as claimed in claim 6, wherein the device further comprises calibration means for defining a reference

inclination of the device, such that at the reference inclination of the device, the portion to be displayed is constant.

8. A hand-held image display device as claimed in any preceding claim, comprising a hand-held data processing device.

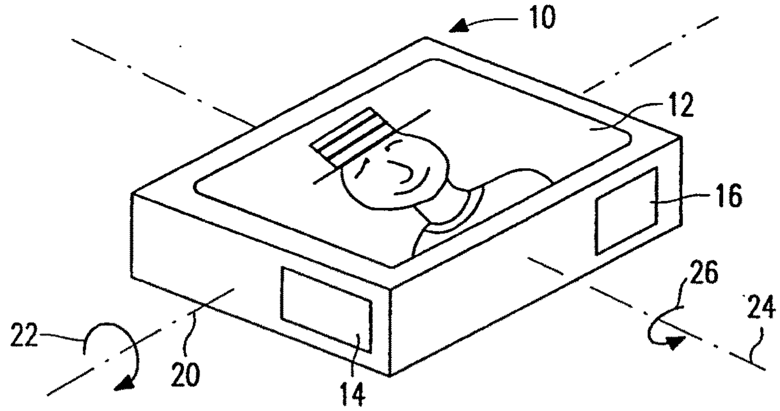

FIG. 1A

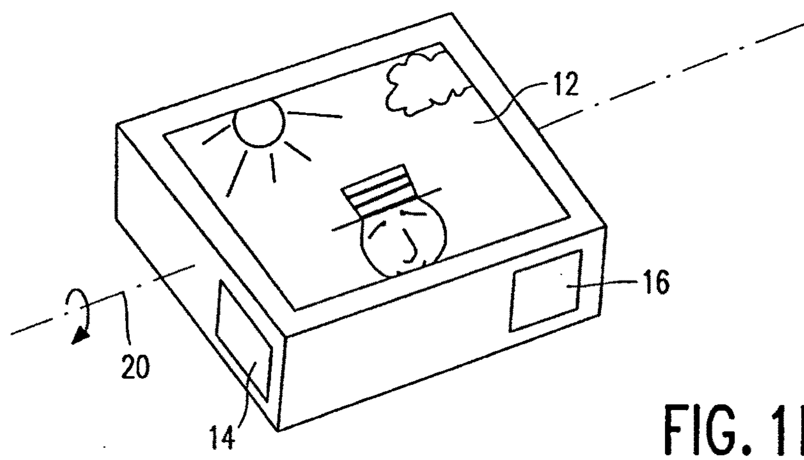

FIG. 1B

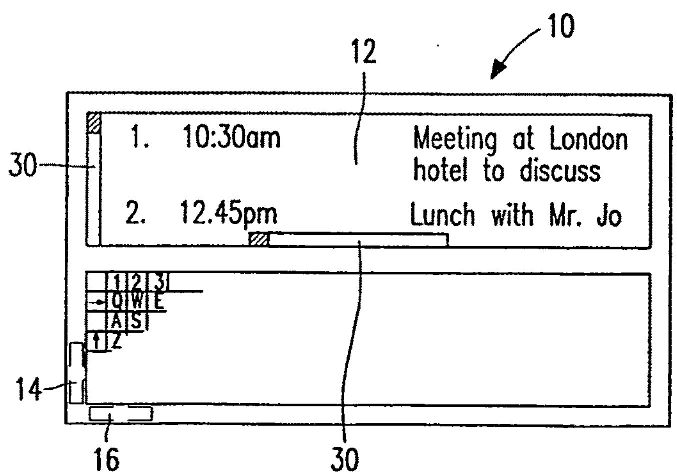

FIG. 2

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

PCT

(43) International Publication Date
2 March 2006 (02.03.2006)

(10) International Publication Number
WO 2006/023569 A1

(51) International Patent Classification:
G06F 3/044 (2006.01)

(21) International Application Number:
PCT/US2005/029270

(22) International Filing Date: 15 August 2005 (15.08.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/522,107 16 August 2004 (16.08.2004) US

(71) Applicant *(for all designated States except US)*: **FINGER-WORKS, INC.** [US/US]; P.O. Box 430, Townsend, DE 19734 (US).

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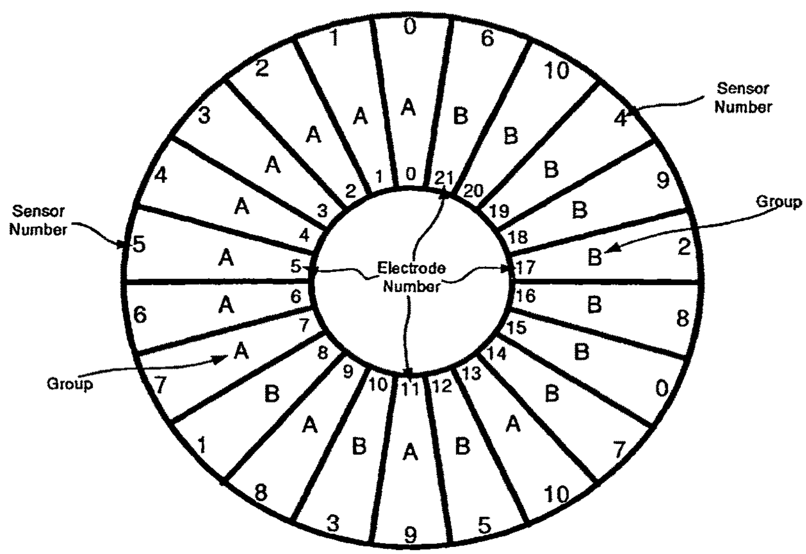
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A METHOD OF INCREASING THE SPATIAL RESOLUTION OF TOUCH SENSITIVE DEVICES



(57) Abstract: Disclosed herein is a capacitive touch sensitive device. One aspect of the touch sensitive device described herein is a reduction in the number of sensor circuits needed for circular or linear capacitive touch sensitive devices while maintaining the same resolution and absolute position determination for a single object. A related aspect of the touch sensitive device described herein a coding pattern that allows each sensor circuit of a capacitive touch sensitive device to share multiple electrodes at specially chosen locations in a sensor array such that the ability to determine the absolute position of a single object over the array is not compromised.

WO 2006/023569 A1

A METHOD OF INCREASING THE SPATIAL RESOLUTION OF TOUCH SENSITIVE DEVICES

Cross-reference to Related Applications

[0001] This application is related to and claims priority to Provisional United States Patent Application Serial No. 60/522,107, filed August 16, 2004, having the same title and inventors as herein, which provisional application is hereby incorporated by reference in its entirety.

Background

[0002] The present invention relates generally to the field of touch sensitive devices, and, in particular, to the field of optimizing capacitive sensing electrode shape and arrangement to increase the effective spatial resolution and/or the physical range of the sensing device using a limited number of sensors.

[0003] In a capacitive touch sensitive device, each sensor, of which there may be many, comprises a conductive pad that forms one plate of a capacitor and a way to measure the capacitance of the conductive pad in conjunction with another movable conductive object. The movable conductive object is typically a finger or stylus that is kept at a minimum distance from the conductive pad by a non-conductive spacer. The two conductive objects (conductive pad and movable conductive object), along with the non-conductive dielectric between them, form a capacitor. As known to those skilled in the art, the capacitance of this capacitor changes as the distance and/or overlap between the objects changes. In a typical device the number of conductive pads (henceforth called electrodes), the size of the electrodes, and the spacing between the electrodes determine the physical range and spatial resolution of the touch sensitive device.

[0004] In typical implementations of capacitive touch sensitive devices the position of a finger gliding over a dielectric-covered array of sensor electrodes is determined by observing the change in capacitance as the finger moves on the surface. Scanning and processing circuitry measures the change in capacitance due to the varying overlap between the finger and a given electrode. If a finger is large enough to partially overlap multiple neighboring electrodes then interpolation allows the finger position to be determined to a resolution much higher than the electrode spacing. The interpolation calculation follows the classic centroid formula: the sum of the signal values at each electrode is multiplied by its coordinate and divided by the sum of all the signal values. This technique works equally well with linear arrays of row and column electrodes, radial arrays of electrodes arranged as spokes in a wheel, or two-dimensional arrays of electrodes arranged to fill a planar space. Special electrode shapes intended to boost interpolation accuracy or resolution are the main distinction between the various related art designs.

[0005] For example, U.S. Patent 5,463,388 to Boie et al., which is hereby incorporated by reference, teaches fingertip sized, interleaved electrode spirals to minimize the number of electrodes needed for a multi-touch sensor array. The interleaving ensures that a finger overlaps multiple electrodes even when centered on a particular electrode and electrodes are one fingertip width apart. Stable interpolation generally requires continual finger overlap with multiple electrodes.

[0006] Seonkyoo Lee, "A Fast Multiple-Touch-Sensitive Input Device," Master's Thesis, University of Toronto (1984) teaches virtual grouping of square electrode cells to more quickly determine whether an object is present within a neighborhood. U.S. Patent 5,767,457 to Gerpheide teaches locating an object by finding the balance point of a virtual grouping of electrodes on either side of the object. Both of these references are hereby incorporated by reference.

[0007] Finally, U.S. Patents 5,543,590; 5,543,591; 5,880,411; and 6,414,671; each assigned to Synaptics and hereby incorporated by reference, teach dense interleaving of row and column spanning electrodes in the same plane by shaping each row electrode as a connected string of diamond shapes, and each column electrode as a string of diamond shapes with centers offset from the row diamond centers.

[0008] However, additional improvement in resolution is still desired for such devices. Although resolution may be increased by adding additional sensor elements, dictates of scanning time, circuitry cost, and power consumption simultaneously drive systems towards as few sensor elements as possible. Therefore, there is a need in the art of sensor array design for sensor arrangements that maximize resolution with a limited number of sensors. Disclosed herein is a touch sensitive device that addresses the needs of the prior art for increased resolution and decreased sensor element count.

Summary

[0009] Disclosed herein is a capacitive touch sensitive device. One aspect of the touch sensitive device described herein is a reduction in the number of sensor circuits needed for circular or linear capacitive touch sensitive devices while maintaining the same resolution and absolute position determination for a single object. A related aspect of the touch sensitive device described herein a coding pattern that allows each sensor circuit of a capacitive touch sensitive device to share multiple electrodes at specially chosen locations in a sensor array such that the ability to

determine the absolute position of a single object over the array is not compromised.

Brief Description of the Drawings

[0010] Figure 1 illustrates a touch sensitive device employing certain teachings of the present invention.

Detailed Description

[0011] A capacitive touch sensor is described herein. The following embodiments of the invention are illustrative only and should not be considered limiting in any respect.

[0012] The touch sensitive device described herein allows each sensor circuit to share two or more electrodes by dispersing the shared electrodes in a particular pattern. The electrodes are shared in the sense that they both electrically connect to the same capacitive measuring sensor circuit through a common conductor without the need for multiplexing switches. Preferably, the distance separating a pair of shared electrodes, i.e., the dispersal distance, is one-third the number of electrodes in the device. The touch sensitive device employed herein further includes a particular coding pattern so that: 1) adjacent electrodes never share the same sensor circuit; and 2) the electrodes sharing the same sensor circuit are always separated from one another by the dispersal distance, i.e., roughly one third of the number of electrodes.

[0013] A touch sensitive device incorporating the teachings herein is illustrated in Fig. 1. The capacitive touch sensitive device 100 is a one-dimensional circular array, although other arrangements, e.g., linear arrays, etc., could also be used. The circular array includes 22 electrodes, numbered 0–21. The circular array includes only 11 sensor circuits. These sensor circuits may take the form of various sensor circuits known to those skilled in the art. One such circuit is disclosed in U.S. Patent 6,323,846, entitled "Method and Apparatus for Integrating Manual Input," which is hereby incorporated by reference. The sensor circuit corresponding to each electrode is designated by a number located at the outer portion of each sensor electrode.

[0014] The touch sensitive device 100 thus shares two electrodes per sensor. However, additional electrodes may be shared with each sensor. Each electrode in Fig. 1 also includes a group designator, either "A" or "B". Each group A electrode shares a sensor with a group "B" electrode. As noted above, the preferred dispersal distance (*i.e.*, the distance between two electrodes sharing a sensor) is a span of approximately one-third the number of sensors, and thus approximately one-third of a characteristic dimension of the device. Thus for the circular device illustrated in Fig. 1, the preferred dispersal distance is approximately one-third the circumference of the circle, thus encompassing approximately one third of the sensors. Any two adjacent electrodes and the two electrodes that share sensor circuits will thus be evenly spaced, a third of the way around the circle. For example, electrode 1 in group A shares sensor 1 with electrode 8 in group B. Electrode 1 is located at approximately the eleven o'clock position, while electrode 8 is located at approximately the seven o'clock position. Similarly, electrode 0 in group A shares sensor 0 with electrode 15 in group B. Electrode 0 is located at the twelve o'clock position, while electrode 15 is located at approximately the four o'clock position.

[0015] The sensor may alternatively be constructed as a one-dimensional linear array. For such a sensor, the dispersal pattern is basically the same as for a circular array: linear arrays can be treated as a circular array that has been broken between two electrodes and uncurled. Again, it is preferred that the dispersal difference between two electrodes sharing a sensor be about one-third the characteristic dimension of the device, which for a linear sensor is the length of the device.

[0016] Obviously, because multiple electrodes share a sensing circuit, the absolute position of an object in contact (proximity) with a single electrode cannot be determined. For absolute position interpolation to work properly in a device constructed according to the principles herein, each electrode must be sufficiently narrow enough that the object being tracked, usually a finger or conductive stylus, overlaps multiple (*e.g.*, two or three) adjacent electrodes. Likewise, to eliminate any ambiguity, the object being tracked must be smaller than the dispersal distance so that it does not overlap both shared electrodes of any sensor circuit.

[0017] While other electrode sharing patterns are possible, some of these can not be used to unambiguously determine the position of a finger. For example, an electrode arrangement with a dispersal distance of half the array size would fail. For a circular array, this would correspond to sharing of electrodes on opposite sides of the circle, 180 degrees from one another. No matter how decoding and interpolation were done, the system could never tell whether the finger or stylus was really at the opposite position halfway around the circle.

[0018] Because each sensor circuit is connected to multiple electrodes, the sensor illustrated herein requires a decoding method that finds the set of electrodes with the largest signals, then decides which of two possible electrode groups would attribute these largest signals to adjacent rather than scattered electrodes. Once this best decoding is known, classic centroid interpolation can commence amongst the adjacent electrodes. For purposes of centroid computation, each sensor's entire signal is attributed to its electrode in the adjacent group, leaving its other electrode from the dispersed group with zero signal and zero contribution to the centroid. Assuming the signal to noise ratio of the sensor circuits is adequate, the sensor described herein offers the same position resolution as a conventional position detector that has a separate sensor circuit for each electrode.

[0019] The example of computer instructions below demonstrates the algorithm used in the present invention to find the position of a finger or stylus that is touching somewhere on the circular array of electrodes. Sensor and electrode mappings are held in look-up-tables (LUTs) to minimize the computation needed for decoding the location of the touching finger. The LUTs map electrode number to sensor number for each group (Sensor_to_A_type_electrode, Sensor_to_B_type_electrode), map the sensor number corresponding to the adjacent electrode (next_X_electrode_sensor, previous_X_electrode_sensor, where X = A or B), and electrode number to sensor number (Electrode_to_Sensor). The use of these LUTs simplifies the calculation of the finger location using the present invention but they are not necessary.

[0020] A brief description of the algorithm implemented by the code is as follows:

1. The sensor array is scanned and the signal values corresponding to each sensor are collected.
2. The sensor having maximum strength signal is located using code segment findMaxSensor.
3. The electrode under which the finger is located is computed using code segment findMaxElectrode.
4. The centroid is computed using code segment computeCentroid.
5. Steps 1 – 4 are repeated.

```
#define NUM_SENSORS 11
#define NUM_ELECTRODES 22


// Group A electrode and sensor mappings
Sensor_to_A_type_electrode[NUM_SENSORS] = {0,1,2,3,4,5,6,7,9,11,13};
next_A_electrode_sensor[NUM_SENSORS] = {1,2,3,4,5,6,7,1,3,5,7};
previous_A_electrode_sensor[NUM_SENSORS] = {6,0,1,2,3,4,5,6,1,3,5};

// Group B electrode and sensor mappings
Sensor_to_B_type_electrode[NUM_SENSORS] = {15,8,17,10,19,12,21,14,16,18,20};
next_B_electrode_sensor[NUM_SENSORS] = {8,8,9,9,10,10,0,0,2,4,6};
previous_A_electrode_sensor[NUM_SENSORS] = {7,7,8,8,9,9,10,10,0,2,4};

// Electrode to sensor mapping
Electrode_to_Sensor[NUM_ELECTRODES] = {

            0, // 0
            1, // 1
            2, // 2
            3, // 3
            4, // 4
            5, // 5
            6, // 6
            7, // 7
            1, // 8
            8, // 9
            3, // 10
            9, // 11
            5, // 12
            10, // 13
            7, // 14
            0, // 15
            8, // 16
            2, // 17
            9, // 18
            4, // 19
            10, // 20
            6  // 21
        };


        // This code finds the sensor that has the strongest signal
        void findMaxSensor(void) {
          unsigned char maxval, i;

          max_sensor = 0;
          maxval = 0;

          for (i = 0; i < NUM_SENSORS; i++) {
            if (SensorData[e] > maxval) {
                maxval = SensorData[i];
                max_sensor = i;
```

```
      }
    }

}
```

// This code finds the electrode that has the strongest signal
// It starts by examining the electrodes adjacent to those electrodes that
// belong to the maximum sensor. The electrode being touched is identified
// by comparing the signal strength of the two electrodes on either side
// of the electrodes belonging to the maximum sensor. The group with the
// largest signal is the one under the touching finger.

```
void findMaxElectrode(void) {
   int Asum, Bsum;

   Asum = SensorData[next_A_electrode_sensor[max_sensor]] +
            SensorData[previous_A_electrode_sensor[max_sensor]];

   Bsum =  SensorData[next_A_electrode_sensor[max_sensor]] +
            SensorData[previous_B_electrode_sensor[max_sensor]];

   if (Asum > Bsum) {
      maxelectrode = Sensor_to_A_type_electrode[max_sensor];
   } else {
      maxelectrode = Sensor_to_B_type_electrode[max_sensor];
   }
}
```

// This code computes the centroid corresponding to the touching finger
// using the location decoded using the algorithm of the invention.

```
#define CENTMULTIPLIER 8

void computeCentroid(void) {
   int pos_sum, electrode;
   char offset;
   int sval;

   pos_sum = 0;
   total_signal = 0;

   //sum from maxelectrode in positive direction for two electrodes
  for (offset = 1; offset < 3; offset++) {
```

```
        electrode = maxelectrode + offset;

        if (electrode >= NUM_ELECTRODES) {
           electrode -= NUM_ELECTRODES;
        }
        sval = SensorData[Electrode_to_Sensor[electrode]];

        total_signal += sval;
        pos_sum += CENTMULTIPLIER*sval*offset;

    }

      //sum from maxelectrode in negative direction for two electrodes
      for (offset = 1; offset <3; offset++) {

        electrode = maxelectrode - offset;

        if (electrode < 0) {
           electrode += NUM_ELECTRODES;
        }
        sval = SensorData[Electrode_to_Sensor[electrode]];

        total_signal += sval;
        pos_sum -= CENTMULTIPLIER*sval*offset;

    }

    total_signal += SensorData[maxe];
    sval = pos_sum/total_signal;
    sval += CENTMULTIPLIER*maxelectrode; //absolute offset by
maxelectrode
    if(sval < 0) {
      Centroid = 176 + sval;
    }
    else {
      Centroid = sval;
    }


}
```

[0021] While the invention has been disclosed with respect to a limited number of embodiments, numerous modifications and variations will be appreciated by those skilled in the art. It is intended that all such variations and modifications fall with in the scope of the following claims.

What is claimed is:

1. A touch sensitive device comprising:
   a plurality of touch sensitive electrodes; and
   a number of sense circuits, wherein the number of sense circuits is less than the number of touch sensitive electrodes such that at least one sense circuit is shared between more than one of the touch sensitive electrodes;
   wherein each of the touch sensitive electrodes that share a sense circuit are spatially separated from each other by a dispersal distance and wherein each touch sensitive electrode is directly connected to a sense circuit.

2. The touch sensitive device of claim 1 wherein the dispersal distance is approximately one-third of a characteristic dimension of the touch sensitive device.

3. The touch sensitive device of claim 1 wherein each sense circuit is directly connected to two touch sensitive electrodes

4. The touch sensitive device of claim 1 wherein the plurality of touch sensitive electrodes are arranged in a circular array.

5. The touch sensitive device of claim 4 wherein the dispersal distance is approximately one-third the circumference of the circular array.

6. The touch sensitive device of claim 4 wherein each sense circuit is directly connected to two touch sensitive electrodes.

7. The touch sensitive device of claim 1 wherein the touch sensitive electrodes are arranged in a linear array.

8. The touch sensitive device of claim 7 wherein the dispersal distance is approximately one-third the length of the linear array.

9. A method of tracking an object used in conjunction a touch sensitive device, wherein the touch sensitive device comprises a plurality of electrodes and a plurality of sense circuits, wherein at least one of the sense circuits is directly connected to more than one electrode, the method comprising:

scanning the plurality of sense circuits to collect a signal value corresponding to each of the plurality of sense circuits;

identifying a sense circuit having a maximum signal value;

identifying an electrode having a maximum signal value, the electrode corresponding to the sense circuit having a maximum signal value; and

computing a centroid of the object being tracked with reference to the electrode having the maximum signal value and adjacent electrodes.

10. The method of claim 9 wherein sensor and electrode mappings required for identifying a sense circuit having a maximum signal value and identifying an electrode having a maximum signal value are stored in look up tables.

11. The method of claim 9 wherein identifying an electrode having a maximum signal value comprises:

picking out each electrode associated with the sense circuit having a maximum signal value;

finding each electrode adjacent the electrodes associated with the sense circuit having a maximum signal value;

comparing signal values associated with the adjacent electrodes; and identifying the electrode having a maximum signal by selecting the electrode having adjacent electrodes with the highest signal value.

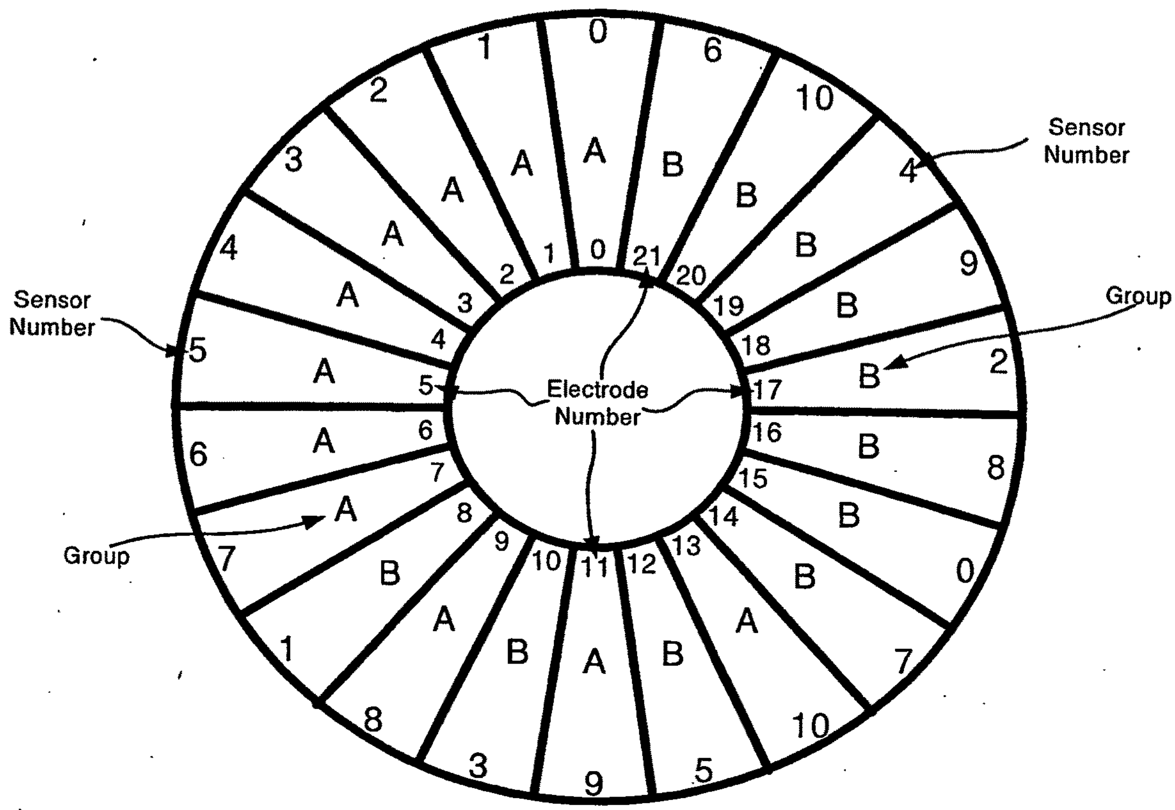

Sensor Number
Sensor Number
Group
Group
Electrode Number
0
1
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Figure 1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/029270

A. CLASSIFICATION OF SUBJECT MATTER
G06F3/044

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 733 222 A (EVANS ET AL) 22 March 1988 (1988-03-22) figures 1,2 figures 10-16 column 4, line 45 - column 5, line 46 column 6, line 12 - column 7, line 15 column 8, line 4 - column 9, line 9 column 10, lines 54-38 column 11, line 10 - column 13, line 29 column 16, line 4 - column 17, line 24 column 18, line 65 - column 19, line 15 column 20, line 34 - column 21, line 51 -----	1-3,7-11
X	WO 03/088176 A (SYNAPTICS, INC) 23 October 2003 (2003-10-23) figure 30 page 18, line 36 - page 19, line 24 -----	1-6
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 January 2006	12/01/2006

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Piriou, Y.N.

International Application No
PCT/US2005/029270

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 788 384 A (BRUERE-DAWSON ET AL) 29 November 1988 (1988-11-29) figure 1 column 2, lines 21-68 column 3, lines 8-12 column 3, lines 60-63 column 5, lines 18-59	1-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2005/029270

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		DE 3770438 D1	04-07-1991
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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 014 295 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
09.01.2002 Bulletin 2002/02

(51) Int Cl.7: G06K 11/06, G06K 11/08, G06K 11/18, G06F 3/033

(43) Date of publication A2:
28.06.2000 Bulletin 2000/26

(21) Application number: 99125631.4

(22) Date of filing: 22.12.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 25.12.1998 JP 36999898
25.12.1998 JP 36999998

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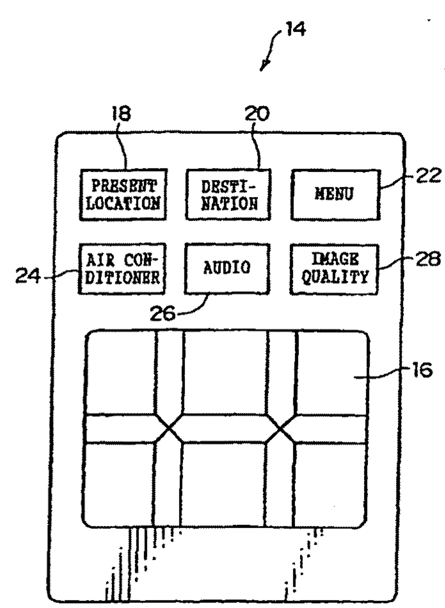
(54) Touch-operating input device, display system, and touch-operating assisting method for touch-operating input device

(57) A touch-operation guide shape is formed on an input pad for inputting a touch operation by variably deforming the surface of the input pad, forming grooves or the like to enable a user to recognize the operation position on the input pad through finger touch. In addition, an image representing the touch-operation guide shape is displayed on a menu frame of a display together with selection items, whereby the corresponding position on the input pad can be recognized on the screen of the display.

F I G. 2



EP 1 014 295 A3

Printed by Jouve, 75001 PARIS (FR)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 12 5631

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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	* column 6, line 10 - line 38 *		
A	* column 8, line 49 - column 9, line 1; figures 1-3,12 *	3-7	
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 561 (P-1142), 13 December 1990 (1990-12-13) & JP 02 240715 A (MATSUSHITA ELECTRIC IND CO LTD), 25 September 1990 (1990-09-25) * abstract *	1,2,10, 11,20	
E	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 09, 13 October 2000 (2000-10-13) & JP 2000 181629 A (NEC CORP), 30 June 2000 (2000-06-30) * abstract *	1-5, 7-11,19	
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A	* page 14, line 30 - line 34; figures 2,4 *	12-14	
A	WO 98 09446 A (HO SENG BENG) 5 March 1998 (1998-03-05) * page 52, line 1 - line 22; figure 9 *	12-14	
A	WO 98 08241 A (ERICSSON TELEFON AB L M) 26 February 1998 (1998-02-26) * abstract; claims; figures *	12-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	13 November 2001	Durand, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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D : document cited in the application
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& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 12 5631

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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13-11-2001

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JP 2000181629	A	30-06-2000	NONE			
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			US	6072475	A	06-06-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 621 989 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
17.05.2006 Bulletin 2006/20

(51) Int Cl.:
G06F 3/033 (2006.01) H04H 7/00 (2006.01)

(43) Date of publication A2:
01.02.2006 Bulletin 2006/05

(21) Application number: 05254654.6

(22) Date of filing: 27.07.2005

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: 30.07.2004 US 903964
17.12.2004 US 15978

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(54) **Touch-sensitive electronic apparatus for media applications, and methods therefor**

(57) An electronic apparatus, such as an electronic mixing apparatus and an electronic keyboard apparatus, and associated methods are disclosed. The electronic mixing apparatus or the electronic keyboard apparatus is provided on a touch screen that provides user input and display capabilities. In one embodiment, the touch screen is a multipoint touch screen so that multiple user touch inputs can be simultaneously acquired. In another embodiment, surface guides can be provided on the touch screen to assist with user input.

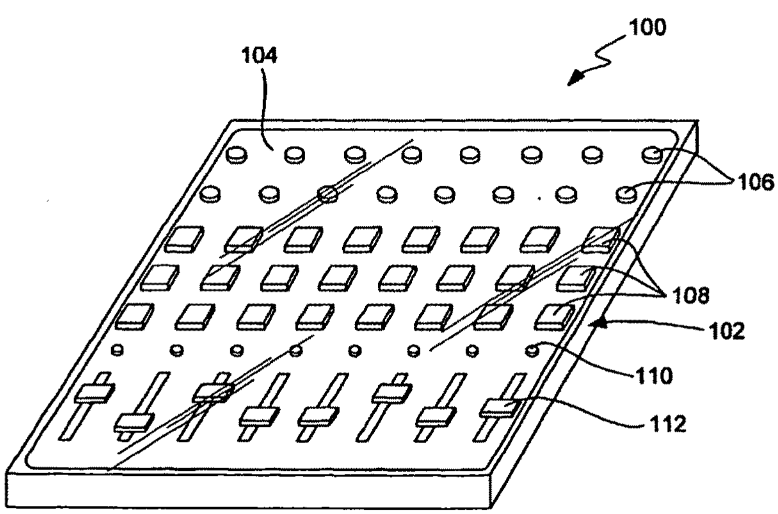

FIG. 1

EP 1 621 989 A3

Printed by Jouve, 75001 PARIS (FR)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 4654

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Y	US 2003/164820 A1 (KENT JOEL) 4 September 2003 (2003-09-04) * abstract * * paragraph [0081] - paragraph [0083] * -----	11-14, 26-35, 44,45, 48-52, 54-56,58	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 March 2006	Valin, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 4654

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 March 2006	Valin, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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12

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 05 25 4654

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The members are as contained in the European Patent Office EDP file on
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27-03-2006

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 February 2006 (23.02.2006)

PCT

(10) International Publication Number
WO 2006/020304 A2

(51) International Patent Classification: Not classified

(21) International Application Number: PCT/US2005/025641

(22) International Filing Date: 19 July 2005 (19.07.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

10/903,964	30 July 2004 (30.07.2004)	US
60/592,483	30 July 2004 (30.07.2004)	US
11/038,590	18 January 2005 (18.01.2005)	US

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(75) Inventors/Applicants (*for US only*): **HOTELLING, Steve** [US/US]; 1351 Hidden Mine Road, San Jose, California 95120 (US). **STRICKON, Joshua, A.** [US/US]; 333 Santana Row #212, San Jose, California 95128 (US). **HUPPI, Brian, Q.** [US/US]; 101#2 28th Street, San Francisco, California 94131 (US). **KERR, Duncan, Robert** [GB/US]; 2600 18th Street, #15, San Francisco, California 94110 (US). **CHAUDHRI, Imran** [US/US]; 2713 Sacramento Street, No. 3, San Francisco, California 94115 (US). **CHRISTIE, Greg** [US/US]; 1112 Kelly Drive, San Jose, California 95129 (US). **IVE, Jonathan, P.** [GB/US]; 196 Twin Peaks Blvd, San Francisco, California 94114 (US). **ORDING, Bas** [NL/US]; 1119 Dolores Street, #4, San Francisco, California 94110 (US).

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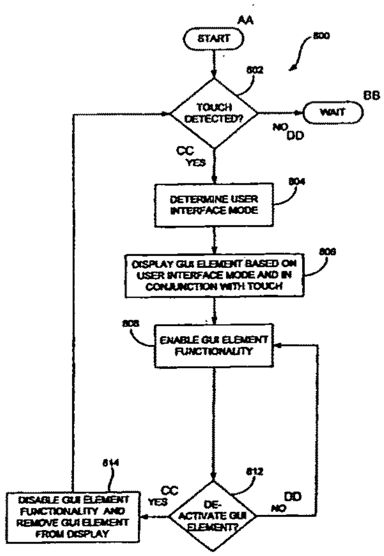
(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL,

[Continued on next page]

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

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



AA DÉBUT
BB ATTENTE
802 DÉTECTION EFFLEUREMENT ?
804 DÉTERMINATION MODE INTERFACE UTILISATEUR
806 AFFICHAGE INTERFACE UTILISATEUR EN FONCTION DU MODE INTERFACE UTILISATEUR ET EN ASSOCIATION AVEC L'EFFLEUREMENT
808 ACTIVATION INTERFACE UTILISATEUR
812 DÉSACTIVATION INTERFACE UTILISATEUR ?
814 DÉSACTIVATION INTERFACE UTILISATEUR ET SON EFFACEMENT DE L'ÉCRAN
CC OUI
DD NON

WO 2006/020304 A2

SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G09G 5/00

A1

(11) International Publication Number: WO 99/38149

(43) International Publication Date: 29 July 1999 (29.07.99)

(21) International Application Number: PCT/US99/01454

(22) International Filing Date: 25 January 1999 (25.01.99)

(30) Priority Data:

60/072,509	26 January 1998 (26.01.98)	US
09/236,513	25 January 1999 (25.01.99)	US

(71)(72) Applicants and Inventors: WESTERMAN, Wayne [US/US]; 715 Oak Street, P.O. Box 354, Wellington, MO 64097 (US). ELIAS, John, G. [US/US]; Huguenot Farm, 798 Taylors Bridge Road, Townsend, DE 19734 (US).

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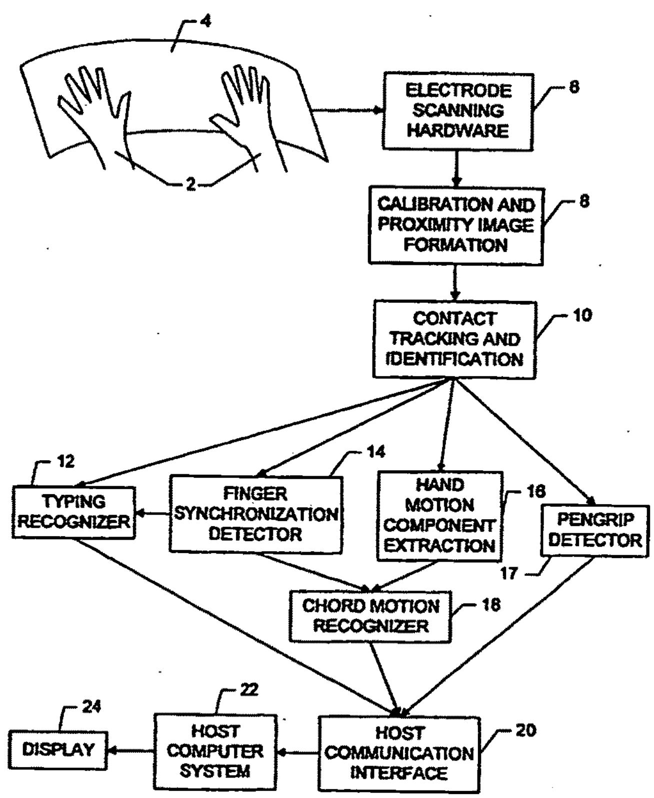
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR INTEGRATING MANUAL INPUT

(57) Abstract

Apparatus and methods are disclosed for simultaneously tracking multiple finger (202–204) and palm (206, 207) contacts as hands approach, touch, and slide across a proximity–sensing, compliant, and flexible multi–touch surface (2). The surface consists of compressible cushion (32), dielectric electrode (33), and circuitry layers. A simple proximity transduction circuit is placed under each electrode to maximize the signal–to–noise ratio and to reduce wiring complexity. Scanning and signal offset removal on electrode array produces low–noise proximity images. Segmentation processing of each proximity image constructs a group of electrodes corresponding to each distinguishable contacts and extracts shape, position and surface proximity features for each group. Groups in successive images which correspond to the same hand contact are linked by a persistent path tracker (245) which also detects individual contact touchdown and liftoff. Classification of intuitive hand configurations and motions enables unprecedented integration of typing, resting, pointing, scrolling, 3D manipulation, and handwriting into a versatile, ergonomic computer input device.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 February 2006 (23.02.2006)

PCT

(10) International Publication Number
WO 2006/020305 A2

(51) International Patent Classification: Not classified

(21) International Application Number: PCT/US2005/025657

(22) International Filing Date: 19 July 2005 (19.07.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/592,483 30 July 2004 (30.07.2004) US
10/903,964 30 July 2004 (30.07.2004) US

(71) Applicant (*for all designated States except US*): **APPLE COMPUTER, INC.** [US/US]; 1 Infinite Loop, Cupertino, California 95014 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **HOTELLING, Steve** [US/US]; 1351 Hidden Mine Road, San Jose, California 95120 (US). **STRICKON, Joshua, A.** [US/US]; 333 Santana Row #212, San Jose, California 95128 (US). **HUPPI, Brian, Q.** [US/US]; 101#2 28th Street, San Francisco, California 94131 (US). **CHAUDHRI, Imran** [US/US]; 2713 Sacramento Street, No. 3, San Francisco, California 94115 (US). **CHRISTIE, Greg** [US/US]; 1112 Kelly Drive, San Jose, California 95129 (US). **ORDING, Bas** [NL/US]; 1119 Dolores Street, #4, San Francisco, California 94110 (US). **KERR, Duncan, Robert** [GB/US]; 2600 18th Street, #15, San Francisco, California 94110 (US). **IVE, Jonathan, P.** [GB/US]; 196 Twin Peaks Blvd, San Francisco, California 94114 (US).

(74) Agent: **HOELLWARTH, Quin, C.**; Beyer Weaver & Thomas, LLP, P. O. BOX 70250, Oakland, California 94612-0250 (US).

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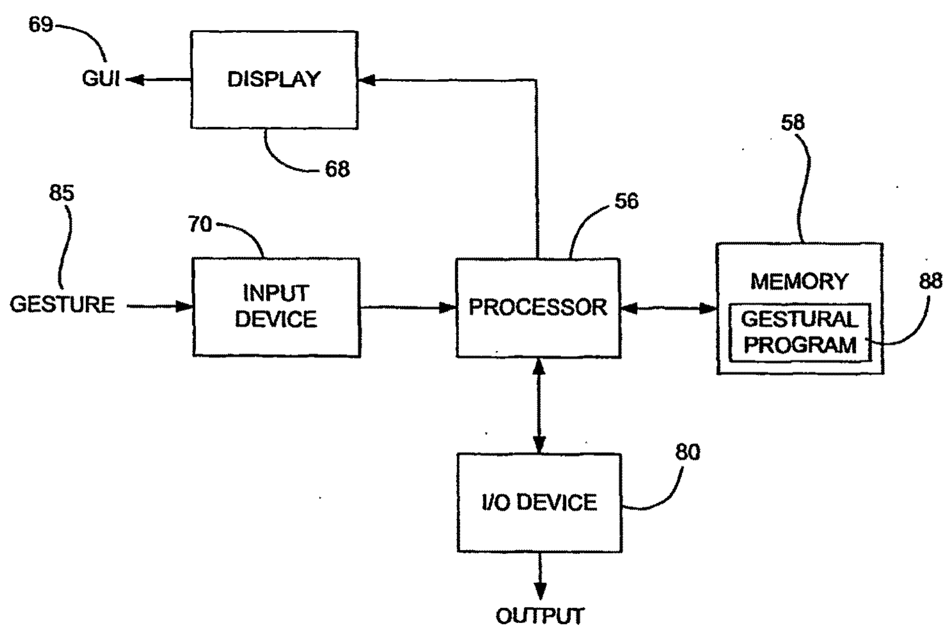
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: GESTURES FOR TOUCH SENSITIVE INPUT DEVICES



(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.

WO 2006/020305 A2

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Human-Computer Interaction – INTERACT '90
D. Diaper et al. (Editors)
Elsevier Science Publishers B.V. (North-Holland)

Force-to-Motion Functions for Pointing

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SELKER@ibm.com

A pointing device which can be operated from typing position avoids time loss and distraction. We have built and investigated force-sensitive devices for this purpose. The critical link is the force-to-motion mapping. We have found principles which enable a force joystick to match the function and approach the performance of a mouse in pure pointing tasks, and to best it in mixed tasks, such as editing. Examples take into account task, user strategy and perceptual-motor limitations.

1. INTRODUCTION

Various workers over the past two decades have investigated and compared a variety of analogue devices for use in computer interface pointing tasks [1, 4]. The usual conclusion has been that the mouse has the advantage over alternatives, and the current commercial fashion seems to agree.

We have been intrigued with the 1.5 [2] or so seconds required to make an excursion from the keyboard to the mouse and return; in applications which intermix pointing and typing, this can be significant. Also, the mouse has other inherent disadvantages, especially in environments which provide restricted space or where dangling wires or loose bits of equipment are a hazard.

Our thesis is that it is possible to point efficiently without moving the hands from the normal touch typing home position. This requires locating the pointing device either in the immediate vicinity of the J or F keys (the index finger being rather clearly the finger of choice), or below the space bar, convenient to the thumbs. We first investigated the use of the J or F keys themselves, to serve for both pointing and typing. This requires that the user tell the computer which use is intended. A number of mode switch possibilities are available, but after preliminary experiments we concluded that the cognitive load of making the switch was serious, and shifted attention to a miniature joy-stick, located between the G and H keys in "no-hands land" where it does not interfere with normal typing. This POINTING STICK is the subject of the studies reported here.

The constraints of space in the keyboard eliminate the kind of position-to-position mapping used for the mouse - hence an isometric or force joystick. We could map force applied to the joystick to the velocity of the cursor, to its position, or perhaps to some combination. We report here on the first choice, the conventional rate joystick. The function relating force to velocity is critical to the performance of the Pointing Stick, and leads to the principle results reported here.

The force joystick has a long history of investigation and use [2]. It has been found that pointing times could be expected to be perhaps 20% slower than for a mouse performing the same tasks. Another concern is the "feel" - the subjective impression of exact control of the cursor, and that its movements are the "natural" response to actions.

Many people find pointing with the position of a mouse natural. Can pointing with a rate joystick also feel natural? The rate joystick appears to have an immediate disadvantage here, since the most natural response to a hand motion (for many people) is a movement of proportional magnitude, independent of duration. An analogous discordance will be recalled by anyone who has taken the controls of a light aircraft for the first time - the aircraft responds to a control offset with a rate of change, not with a direct change. As in that case, we find that users very quickly become accustomed to the rate mode of response, and find it natural.

The less tangible aspect of "feel" is the positive control; here the force to motion function is critical. Good "feel" seems to correlate, up to a point, with the more easily measured speed of pointing tasks, especially with small targets.

This paper reports the result of an investigation of a class of force-to-motion functions (*transfer functions*) and their effect on the speed of several experimental pointing tasks for our in-keyboard pointing device, the Pointing Stick.

2. TRANSFER FUNCTIONS

Our exploration of the space of transfer functions began with three families of mathematically simple

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mappings of force to cursor velocity - linear, parabolic, and a sigmoid parabolic, obtained by reflecting the initial part of the parabola in the point 1/2,1/2 $[(v = f), (v = f^2)$, and $(v = 2 \times f^2, 0 \le f \le 1/2;$ $v = 2 \times (1/2 - (1 - f)^2, 1/2 \le f \le 1; v = 1, f > 1)]$. Force f and velocity v have scale factors (coefficients), making each of these a 2-parameter family of functions. From experience with these functions, we arrived at the following conjectures:

1. A 'solid' feel, that a point can be held, requires a 'dead band' near zero force, in which the cursor does not move, even if the finger is not perfectly steady.

2. Pointing at small targets requires accurate control of low speed motion - one pixel at a time must be possible. This needs to be done without excess strain in fine motor control, hence the slope of the function at low speed should be low.

3. For long-distance cursor movements, high speed is required. However, we found that when eye-tracking became inaccurate, overall speed was reduced. A high-speed dash off the screen, or to somewhere distant from the target, is counter-productive. In less extreme form, one has the impression of playing golf - a long-distance, partially controlled 'drive', followed by "now where is it - oh, there", then perhaps another, shorter shot, recovery, and finally a low-speed 'putt'. This suggests that a limitation of maximum speed to the eye-tracking limit will be desirable.

4. As a final touch, users like to feel that they can make the cursor dash across the screen almost instantly, and there may be occasions when one wants to reach the opposite edge and start again from there. To accommodate this, we add a steep rise near the top of the force scale. This probably adds little if anything to speed of performance, but it does no damage, and seems to increase acceptance.

Of the simple functions, the sigmoid parabolic seems the most promising, according to the conjectures. This was borne out in informal experiments. However, its behavior near zero was less than 'solid'. The addition of a 'dead slow' plateau suggested itself, following a true dead band. This gives no motion at all for very low force, followed by a region of predictably slow motion somewhat independent of force, then followed by a rapid but smooth acceleration. Similarly, in the upper range, we would like to be able to easily 'cruise' just below the eye-hand-tracking limit, without danger of exceeding it. An upper plateau provides this, reached smoothly from the acceleration regime (Figure 1).

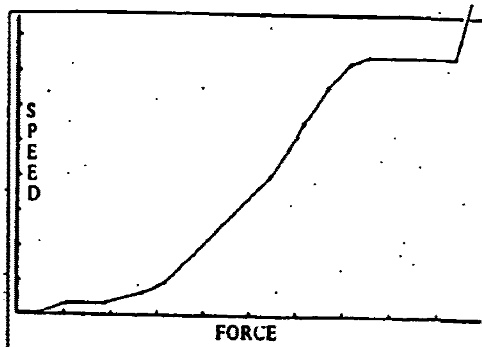

Figure 1. Transfer Function 2Plateau

The ordinate of this graph is force, the abscissa is cursor velocity, in percent of the corresponding scale factors. The velocity scale factor (multiplier of v in the above formulas) is 1500 pixels/second, or on our screen, 66 cm/second. The force scale factor (multiplier of f) was fixed for these experiments at a comfortable value of 225 grams; all sensitivity adjustments were done with the velocity scale.

3. APPARATUS

The Pointing Stick, as used in these experiments, is a steel rod of 2 mm diameter and 2 cm length, mounted on an acrylic base. A section near the base has orthogonal flats to which miniature semiconductor strain gages are bonded (Figure 2).

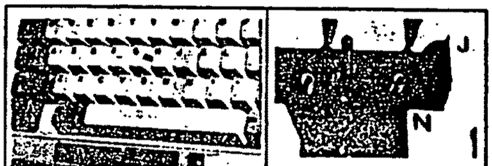

Figure 2. Pointing Stick

The base is glued on the sub-key surface of an IBM PS/2 keyboard, so that the stick protrudes approximately 4 mm above the surface of the keys in their rest position, between the G and H keycaps, which are relieved at their bases to allow space for it. The top is rounded to provide a comfortable fingertip grip. To provide mouse button signals, two microswitches and operating buttons are mounted nearly flush just below the space bar, convenient to the thumbs.

The keyboard was placed about 6 cm from the edge of the desk, allowing subjects to use it as a rest for the heel of the hand. The keyboard retains its normal function as the keyboard of a PS/2 Model 80 computer, which presented and recorded the experiments.