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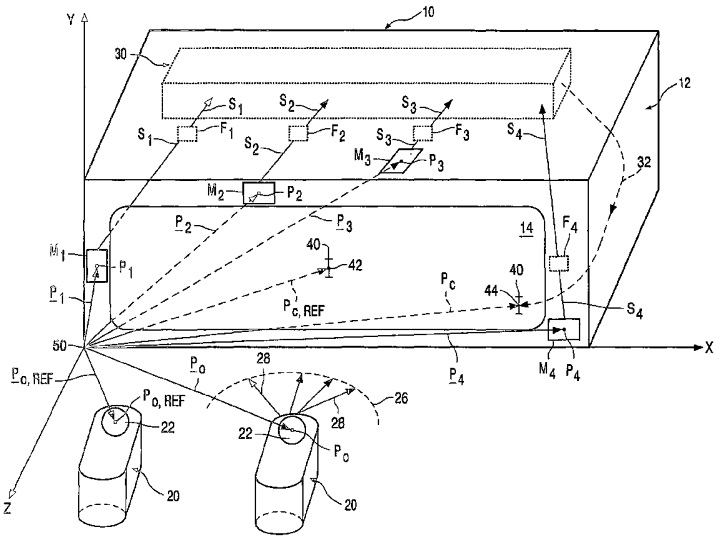
(54) Title: WIRELESS ACOUSTIC BASED POINTING DEVICE, E.G. COMPUTER MOUSE, FOR CONTROLLING A CURSOR ON A DISPLAY SCREEN



(57) Abstract: An acoustic based pointing device and a system and method for using the pointing device to move a cursor on a display screen of a display device. The pointing device comprises an acoustic source that generates and propagates an acoustic signal that is detected by four microphones M1, M2, M3, and M4 and is then converted into corresponding periodic electrical signals S1, S2, S3, and S4. The position vector P0 of the acoustic source is calculated by solving triangulation equations that depend on phase-shift time delays between S1 and Sj for j = 1, 2, and 3. A position vector PC is calculated from P0 using a scale vector that relates a change in position of the cursor to a change in position of the acoustic source. Then the cursor is moved to a position PC associated with the position vector PC.

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WIRELESS ACOUSTIC BASED POINTING DEVICE, E.G. COMPUTER MOUSE, FOR CONTROLLING A CURSOR ON A DISPLAY SCREEN.

Background of the Invention

Technical Field

The present invention relates generally to a system and method for controlling a cursor on a display screen, and more particularly to use of an acoustic based pointing device for controlling the cursor on the display screen.

Related Art

A commercially available wireless pointing device exploits the gyroscopic effect. Consequently, such commercially available wireless pointing devices rely on the rotation of the pointing device which makes these pointing devices very unintuitive and inhibits the ability to track the positions of these pointing devices. Additionally, these pointing devices are fundamentally heavy since they need a large mass in order to exploit conservation of angular momentum.

Accordingly, there is a need for wireless pointing device that eliminate the aforementioned disadvantages of commercial wireless pointing devices that are currently available.

Summary of the Invention

A first embodiment of the present invention provides a method for controlling a cursor on a display screen, comprising:

detecting an acoustic signal at four microphones M_1, M_2, M_3, and M_4, the four microphones being at fixed positions and the acoustic signal being propagated from a wireless pointing device having an acoustic source located at a position P_0 having an associated position vector P_0, wherein P_0 is yet to be calculated;

converting the acoustic signal detected at microphone M_i to a periodic electrical signal S_i, for i=1, 2, 3, and 4;

calculating P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4;

computing a position vector P_C for the cursor, wherein P_C depends on: P_0, a scale vector A, and a shape function of the display screen; and

positioning the cursor at a position P_C associated with the position vector P_C.

A second embodiment of the present invention provides a system for moving a cursor on a display screen, comprising:

a display device having the display screen;

four microphones M_1, M_2, M_3, and M_4 at fixed positions;

a wireless pointing device having an acoustic source, wherein the acoustic source is located at a position P_0 having an associated position vector P_0, wherein the acoustic source is adapted to generate and propagate an acoustic signal, wherein the microphone M_i is adapted to detect the acoustic signal, and wherein the acoustic signal detected at the microphone M_i is adapted to be converted to a periodic electrical signal S_i, for i=1, 2, 3, and 4;

a computing system to which the cursor, S_1, S_2, S_3, and S_4 are each electrically coupled, wherein the computing system is adapted to calculate P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4, and wherein the computing system is adapted to compute a position vector P_C for the cursor such that P_C depends on: P_0, a scale vector A, and a shape function of the display screen; and

means for positioning the cursor at a position P_C associated with the position vector P_C.

A third embodiment of the present invention provides a pointing device, said pointing device being wireless and comprising an acoustic source, wherein the acoustic source is adapted to generate and propagate an acoustic signal comprising a plurality of frequency components.

A fourth embodiment of the present invention provides a computing system, comprising:

an output interface for controlling a display device having a display screen;

an input interface for receiving a periodic electrical signal S_i, for i=1, 2, 3, and 4 from four microphones M_1, M_2, M_3, and M_4 located at fixed positions, each of the four microphones being able to detect an acoustic signal from a wireless pointing device having an acoustic source located at a position P_0 having an associated position vector P_0; and

a control unit able to calculate P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4, able to compute a position vector P_C for the cursor such that P_C depends on: P_0, a scale vector A, and a shape function of the display screen, and able to use the output interface to position the cursor at a position P_C associated with the position vector P_C.

The present invention provides a pointing device that eliminates the disadvantages associated with commercial wireless pointing devices that are currently available. For example, the acoustic based pointing device of the present invention is or may be: wireless, accurate, lightweight, hand held, and easily tracked with respect to its motions and spatial positions. Additionally, the user is able to use the pointing device of the present invention in a way that is analogous to use of a conventional computer mouse with the added advantage that the pointing device of the present invention is wireless.

Brief Description of the Drawings

FIG. 1 depicts a three-dimensional view of a first embodiment of a system for controlling a cursor on a display screen of a display device, in accordance with embodiments of the present invention.

FIG. 2 depicts a three-dimensional view of a second embodiment of a system for controlling a cursor on a display screen of a display device, in accordance with embodiments of the present invention.

Detailed Description of the Invention

FIG. 1 illustrates a three-dimensional view of a first embodiment of a system 10 for controlling a cursor 40 on a display screen 14 of a display device 12, in accordance with embodiments of the present invention. FIG. 1 shows a three-dimensional cartesian coordinate system having three mutually orthogonal axes identified as X, Y, and Z axes having a coordinate origin at the point 50. The Z axis is oriented in a "depth" direction into or out of the display screen 14 as perceived by a viewer who is viewing the display screen 14. The X and Y axes define a plane, namely the X-Y plane, such that the Z axis is normal to the X-Y plane If the display screen 14 has a planar shape, then the display screen 14 is parallel to the X-Y plane. The present invention accounts for the shape of the display screen 14, regardless of whether the display screen 14 is planar or non-planar. Any vector shown in FIG. 1 is a three dimensional vector having components along the X, Y, and Z axes. The system 10 comprises the display device 12, a pointing device 20, four microphones denoted as M_1, M_2, M_3, and M_4, and a computing system 30.

The display device 12 is capable of receiving an image in electronic form and displaying the image visually on the display screen 14. The display device 12 may comprise, *inter alia*, a television, a computer monitor, etc.

The pointing device 20 is capable of controlling motion of a cursor 40 on the display screen 14 of the display device 12. The pointing device 20 may comprise, *inter alia*, a mouse. The pointing device 20 includes an acoustic source 22 that is adapted to continuously generate and propagate an acoustic signal 28 (i.e., longitudinal acoustic waves) through the ambient atmosphere. The acoustic source 22 has an associated wave front 26. The acoustic source 22 is at a position P_0 with an associated position vector P_0. FIG. 1 also shows the acoustic source 22 at a reference position $P_{0,REF}$ with an associated position vector $P_{0,REF}$. Vectors P_0 and $P_{0,REF}$ each have a component along each of the X, Y, and Z axes.

The cursor 40 is at a position Pc having an associated position vector P_C, as measured from the coordinate origin 50. The position Pc may be on the display screen 14, or "behind" the display screen 14 to simulate an apparent depth of the cursor 40 relative to the display screen

14. For the case of no apparent depth, Pc and P_C trace a path on the surface of the display screen 14 as the cursor 40 moves. FIG. 1 also shows the cursor 40 at a position that has an associated reference position vector $P_{C,REF}$. For simplicity, $P_{C,REF}$ may be chosen to be on the display screen 14. Vectors P_C and $P_{C,REF}$ each have a component along each of the X, Y, and Z axes. $P_{C,REF}$ corresponds to $P_{0,REF}$ (i.e., the cursor 40 is at the reference screen position vector $P_{C,REF}$ when the acoustic source 22 is at the reference position $P_{0,REF}$).

The microphones M_1, M_2, M_3, and M_4 are at positions P_1, P_2, P_3, and P_4 with associated position vectors P_1, P_2, P_3, and P_4, respectively. P_1, P_2, P_3, and P_4 each have a component along each of the X, Y, and Z axes. While FIG. 1 shows the microphones M_1, M_2, M_3, and M_4 to be positioned in a particular geometric arrangement on a surface of the display device 12, the microphones M_1, M_2, M_3, and M_4 may be in any geometric arrangement relative to one another such that no three of M_1, M_2, M_3, and M_4 are colinear. Each of the microphones M_1, M_2, M_3, and M_4 may be independently located on, within, or outside of the display device 12.

The computing system 30 may comprise at least one semiconductor chip that has hardware-encoded algorithms. Alternatively, the computing system 30 may comprise a memory and processor (e.g., a computer) for storing and executing software, respectively. The computing system 30 is electrically coupled to the cursor 40 through an electrical path 32 (e.g., electrical wiring), which enables the computing system 30 to control the motion and position of the cursor 40. While FIG. 1 shows the computing system 30 to be located within the display device 12, the computing system 30 could be located on, within, or outside of the display device 12.

The acoustic source 22 continuously generates and propagates the acoustic signal 28. The microphones M_1, M_2, M_3, and M_4 are each adapted to detect the acoustic signal 28. The acoustic signal 28 detected at the microphones M_i is adapted to be converted to a periodic electrical signal (e.g., an alternating current sinusoidal signal) S_i, for i=1, 2, 3, and 4. Each electrical signal of the electrical signals S_1, S_2, S_3, and S_4 is phase-shifted with respect to another signal of the electrical signals S_1, S_2, S_3, and S_4, as a consequence of the difference in magnitude of the distance between the acoustic source 22 at the position P_0 and each of the positions P_1, P_2, P_3, and P_4 of the microphones M_1, M_2, M_3, and M_4, respectively.

The electrical signals S_1, S_2, S_3, and S_4 so generated are each electrically coupled to the computing system 30. If the pointing device 20 has been moved to the position P_0 corresponding to the associated position vector P_0, then the cursor 44 must be moved to its position P_C corresponding to its associated position vector P_C. The computing system 30 is adapted to calculate the position vector P_0 of the acoustic source 22, by processing the electrical signals S_1, S_2, S_3, and S_4. For example, the computing system 30 may calculate P_0 by solving the triangulation equations

$$|P_1-P_0| - |P_j-P_0| = C\Delta T_{1j} \quad (1)$$

for j=2, 3, and 4. ΔT_{ij} is defined as a phase-shift time delay between electrical signals S_1 and S_j, for: i=1, 2, 3, 4; j=1, 2, 3, 4; and $i \neq j$. C is the speed of the acoustic signal 28 in the ambient atmosphere. Equations (1) comprise three equations corresponding to j = 2, 3, and 4, which may be solved simultaneously for the three unknowns P_{0X}, P_{0Y}, and P_{0Z} by any computational method known to a person of ordinary skill in the art of numerical analysis and computation. If the Equations (1) have two solutions for position P_0, the sign of the phase-shift time delay may be used to determine the correct P_0. Alternatively, if only one of the two solutions for position P_0 is in front of the display device 12, this one solution may be determined to be the correct P_0. The unknowns P_{0X}, P_{0Y}, and P_{0Z} are the components of the position vector P_0 along the X, Y, and Z axes, respectively. Note that the scope of the present invention includes any mathematically equivalent form of Equations (1), and includes any other applicable triangulation technique known to a person of ordinary skill in the art. If the computing system 30 comprises at least one semiconductor chip, then the solution to Equations (1) may be hardware-encoded within the at least one semiconductor chip. If the computing system 30 comprises a memory and processor (e.g., a computer), then a solution algorithm for Equations (1) may be stored as software (e.g., as a computer program) in said memory and said software may be executed by said processor.

Following calculation of the position vector P_0 of the acoustic source 22, the vector position P_C of the cursor 44 is calculated via the equations

$$P_{CX} = P_{CX,REF} + A_X (P_{0X} - P_{0X,REF}) \quad (2A)$$

$$P_{CY} = P_{CY,REF} + A_Y (P_{0Y} - P_{0Y,REF}) \quad (2B)$$

$$P_{CZ} = P_{CZ,REF} + A_Z (P_{0Z} - P_{0Z,REF}) + (Z_S(P_{CX}, P_{CY}) - P_{CZ,REF}) \quad (2C)$$

P_{CX}, P_{CY}, and P_{CZ} are the components of P_C along the X, Y, and Z axes, respectively. $P_{CX,REF}$ and $P_{CY,REF}$ and $P_{CZ,REF}$ are the components of $P_{C,REF}$ along the X, Y, and Z axes, respectively. $P_{0X,REF}$ and $P_{0Y,REF}$ and $P_{0Z,REF}$ are the components of $P_{0,REF}$ along the X, Y, and Z axes, respectively. $P_{CZ,REF}$ is assumed to describe a reference coordinate of the cursor 44 on the surface of the display screen 14. $Z_S(P_{CX}, P_{CY})$ is the Z coordinate of the cursor 44 on the surface of the display screen 14 at P_{CX} and P_{CY} (i.e., at the X and Y coordinates of the cursor 44). Generally, $Z_S(X,Y)$ is the Z coordinate of the surface of the display screen 14 as a function of X and Y. Thus, $Z_S(X,Y)$ is a "shape function" the display screen 14. If the display screen 14 is planar, then $Z_S(P_{CX}, P_{CY}) = P_{CZ,REF}$ (i.e., the shape function is "flat") and Equation (2C) for P_{CZ} simplifies to $P_{CZ} = P_{CZ,REF} + A_Z (P_{0Z} - P_{0Z,REF})$, which is of the same form as Equations (2A) and (2B) for P_{CX} and P_{CY}, respectively. However, the display screen 14 may be non-planar such that $Z_S(X,Y)$ is not constant and $Z_S(P_{CX}, P_{CY}) \neq P_{CZ,REF}$ ((i.e., the shape function is "not flat"). The scope of the present invention includes any mathematically equivalent form of Equations (2A), (2B), and (2C).

Following calculation of P_C, the cursor 44 is moved to the position P_C in response to movement of the pointing device 20 to the position P_0. The physical motion of the cursor 44 to the position P_C is accomplished by using any electronics and hardware that is known to a person of ordinary skill in the art. The quantities A_X, A_Y, and A_Z are components of a scale vector A and are scale factors in the X, Y, and Z directions, respectively; i.e., the scale vector A governs the magnitude of the movement of the cursor 44 in response to the corresponding movement of the pointing device 20. In accordance with Equations (2A) and (2B), A_X and A_Y govern motion of the cursor 44 in the X-Y plane. In accordance with Equation (2C), $(Z_S(P_{CX}, P_{CY}) - P_{CZ,REF})$ is the change in the Z coordinate of the cursor 44 from the reference cursor Z-coordinate $P_{CZ,REF}$, due to the non-planarirty of the shape of the surface of the display screen 14. Also in accordance with Equation (2C), A_Z governs motion of the cursor 44 in an "apparent depth" (i.e., along the Z axis). Since, the cursor 44 cannot physically move away from the display screen 14, the motion of the cursor 44 in the depth direction is apparent, rather than real, in light of the ability of human vision to perceive depth in relation to a visual image that appears on the display screen 14. The scale factors A_X, A_Y, and A_Z may be constants that have been determined prior to the calculation of P_C via Equation (2A), (2B), and (2C). Alternatively, A_X, A_Y, and A_Z may be spatially dependent in order to simulate scaling that varies with spatial location of the cursor 44.

As a first example, a scale factor A_X of 0.5 cm/inch denotes that the cursor 44 moves 0.5 cm in the X direction per inch of movement of the acoustic source 22 (and thus also the pointing device 20) in the X direction. As a second example, a scale factor A_X of 0.1 inch/inch denotes that the cursor 44 moves 0.1 inches in the X direction per inch of movement of the acoustic source 22 (and thus also the pointing device 20) in the X direction. As a third example, a scale factor A_X of 600 pixels/inch denotes that the cursor 44 moves 600 pixels in the X direction per inch of movement of the acoustic source 22 (and thus also the pointing device 20) in the X direction. The preceding examples also apply analogously for A_Y and A_Z in relation to motion in the Y and Z directions, respectively, while recognizing that the depth motion of the cursor 44 in the Z direction is apparent motion rather than real motion.

The case of $A_Z = 0$ restricts all motion (i.e., real and apparent motion) of the cursor 44 to the surface of the display screen 14, with no motion in the depth direction (i.e., behind the display screen 14). Thus if $A_Z = 0$, any motion of the acoustic source 22 (and thus also the pointing device 20) in the Z direction (or the -Z direction) will have no effect on the position of the cursor 44 on the display screen 14. In order for the cursor 44 to have apparent motion away or toward the display screen 14, the condition $A_Z \neq 0$ must be satisfied.

The acoustic source 22 could generate the acoustic signal 28 at any acoustic frequencies. It is beneficial, however, for the acoustic source 22 to generate the acoustic signal 28 at frequencies above those frequencies that can be heard by a human being (i.e., above about 20kHz). Additionally, the phase-shift time delay period ΔT_{ij} (defined *supra*) should be less than the period T of the acoustic signal 28 so that ΔT_{ij} could be unambiguously calculated from comparison of the electrical signals S_1 and S_j (for j = 2, 3, and 4). It is noted that sound travels in air at room temperature at a speed (C) of about 1100 ft/sec, so that a value of 1 ft for $(|P_1-P_0| - |P_2-P_0|)$ has an associated phase-shift time delay period ΔT_{12} of less than 1 msec (see Equation (1)). Since a frequency of 20kHz has a period of 50 microseconds, the acoustic signal 28 should include at least two discrete frequencies. For example, a composite signal of two frequencies, whose periods are 47 microseconds and 49 microseconds, would have a period of about 2.3 msec. As another example, a composite signal of three frequencies, whose periods are 43 microseconds, 47 microseconds, and 49 microseconds, would have a period of about 99 msec. Thus, at frequencies of at least about 20 kHz, the acoustic signal 28 should have at least two frequency components. At frequencies of at least about 20 kHz with the acoustic signal 28 having at least three frequency components, the present invention would benefit from having the period T of the acoustic signal 28 substantially larger than the phase-shift time delay periods ΔT_{ij} (i=1, 2, 3 and j=1, 2, 3 and i≠j).

If the microphones M_1, M_2, M_3, and M_4 are able to detect a range of acoustic frequencies, then the microphones M_1, M_2, M_3, and M_4 could potentially detect frequencies other than those frequencies present in the acoustic signal 28, which may cause erroneous calculations of the phase-shift time delay periods ΔT_{ij} (i=1, 2, 3 and j=1, 2, 3 and i≠j). Accordingly, filters F_1, F_2, F_3, and F_4 (see FIG. 1) may be used to filter the electrical signals S_1, S_2, S_3, and S_4, respectively, so as to remove from S_1, S_2, S_3, and S_4 all frequency components except those frequency components present in the acoustic signal 28.

FIG. 2 illustrates a three-dimensional view of a second embodiment of a system 10 for controlling a cursor 40 on a display screen 14 of a display device 12, in accordance with embodiments of the present invention. In this embodiment, the four microphones M_1, M_2, M_3, and M_4 are at fixed positions such that no four of the positions of M_1, M_2, M_3, and M_4 are coplanar. This is illustrated by providing the microphone M_3 on top of the system 10 instead of at the front-side of the system 10. Although in FIG.2, the four microphones M_1, M_2, M_3, and M_4 are also at fixed positions such that no three of the positions of M_1, M_2, M_3, and M_4 are colinear, this is not required if no four of the positions of M_1, M_2, M_3, and M_4 are coplanar.

Although the embodiments described herein disclose four microphones, namely M_1, M_2, M_3, and M_4, the scope of the present invention includes N such microphones such that N≥4. If N>4 then the extra N-4 microphones could be used to, *inter alia*, infer more than one value of the position P_0 of the pointer device. Said multiple computed values of P_0 could be averaged to such that the resulting average value of P_0 has improved statistical accuracy as compared with P_0 that would be inferred from exactly four microphones.

While embodiments of the present invention have been described herein for purposes of illustration, many modifications and changes will become apparent to those skilled in the art. Accordingly, the appended claims are intended to encompass all such modifications and changes as fall within the true spirit and scope of this invention. Computer program' is to be understood to mean any software product stored on a computer-readable medium, such as a floppy disk, downloadable via a network, such as the Internet, or marketable in any other manner.

CLAIMS:

1. A system (10) for controlling a cursor (40) on a display screen (14), comprising:

- a display device (12) having the display screen (14);
- four microphones M_1, M_2, M_3, and M_4 at fixed positions;
- a wireless pointing device (20) having an acoustic source (22), wherein the acoustic source (22) is located at a position P_0 having an associated position vector P_0, wherein the acoustic source (22) is adapted to generate and propagate an acoustic signal, wherein the microphone M_i is adapted to detect the acoustic signal, and wherein the acoustic signal detected at the microphone M_i is adapted to be converted to a periodic electrical signal S_i, for i=1, 2, 3, and 4;
- a computing system (30) to which the cursor (40), S_1, S_2, S_3, and S_4 are each electrically coupled, wherein the computing system (30) is adapted to calculate P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4, and wherein the computing system (30) is adapted to compute a position vector P_C for the cursor (40) such that P_C depends on: P_0, a scale vector A, and a shape function of the display screen (14); and
- means for positioning the cursor (40) at a position P_C associated with the position vector P_C.

2. The system (10) of claim 1, wherein the four microphones M_1, M_2, M_3, and M_4 are at fixed positions such that no three of the positions of M_1, M_2, M_3, and M_4 are colinear;

3. The system (10) of claim 1, wherein the four microphones M_1, M_2, M_3, and M_4 are at fixed positions such that no four of the positions of M_1, M_2, M_3, and M_4 are coplanar;

4. The system (10) of claim 1, wherein the display screen (14) is non-planar.

5. The system (10) of claim 1, wherein the acoustic signal comprises a plurality of frequency components.

6. The system (10) of claim 5, wherein each frequency component has a frequency of at least about 20 kHz.

7. The system (10) of claim 5, further comprising a filter adapted to remove from the electrical signal S_i all frequency components except the plurality of frequency components, for i=1, 2, 3, and 4.

8. A computing system (30), comprising:

- an output interface for controlling a display device (12) having a display screen (14);
- an input interface for receiving a periodic electrical signal S_i, for i=1, 2, 3, and 4 from four microphones M_1, M_2, M_3, and M_4 located at fixed positions, each of the four microphones being able to detect an acoustic signal from a wireless pointing device (20) having an acoustic source (22) located at a position P_0 having an associated position vector P_0; and
- a control unit able to calculate P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4, able to compute a position vector P_C for the cursor (40) such that P_C depends on: P_0, a scale vector A, and a shape function of the display screen (14), and able to use the output interface to position the cursor (40) at a position P_C associated with the position vector P_C.

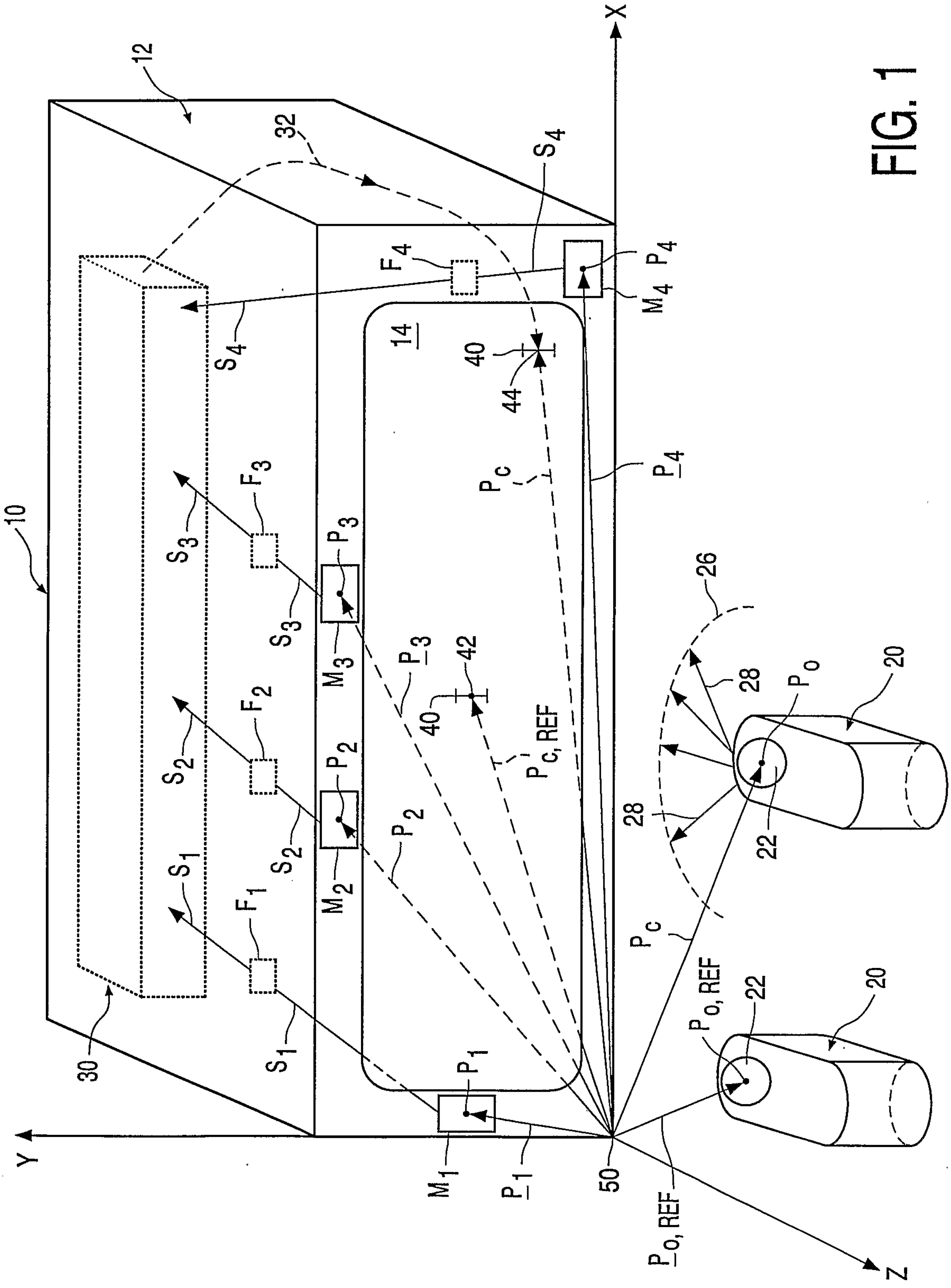
9. A pointing device (20), said pointing device (20) being wireless and comprising an acoustic source (22), wherein the acoustic source (22) is adapted to generate and propagate an acoustic signal comprising a plurality of frequency components.

10. A method for controlling a cursor (40) on a display screen (14), comprising:

- detecting an acoustic signal at four microphones M_1, M_2, M_3, and M_4, the four microphones being at fixed positions and the acoustic signal being propagated from a wireless pointin device (20) having an acoustic source (22) located at a position P_0 having an associated position vector P_0, wherein P_0 is yet to be calculated;

- converting the acoustic signal detected at microphone M_i to a periodic electrical signal S_i, for i=1, 2, 3, and 4;
- calculating P_0 by solving triangulation equations that comprise a dependence on a phase-shift time delay between S_1 and S_j, for j=2, 3, and 4;
- computing a position vector P_C for the cursor (40), wherein P_C depends on: P_0, a scale vector A, and a shape function of the display screen (14); and
- positioning the cursor (40) at a position P_C associated with the position vector P_C.

11. A computer program product enabling a computing system (30) to carry out the method of claim



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P_o
$P_{o, REF}$

FIG. 1

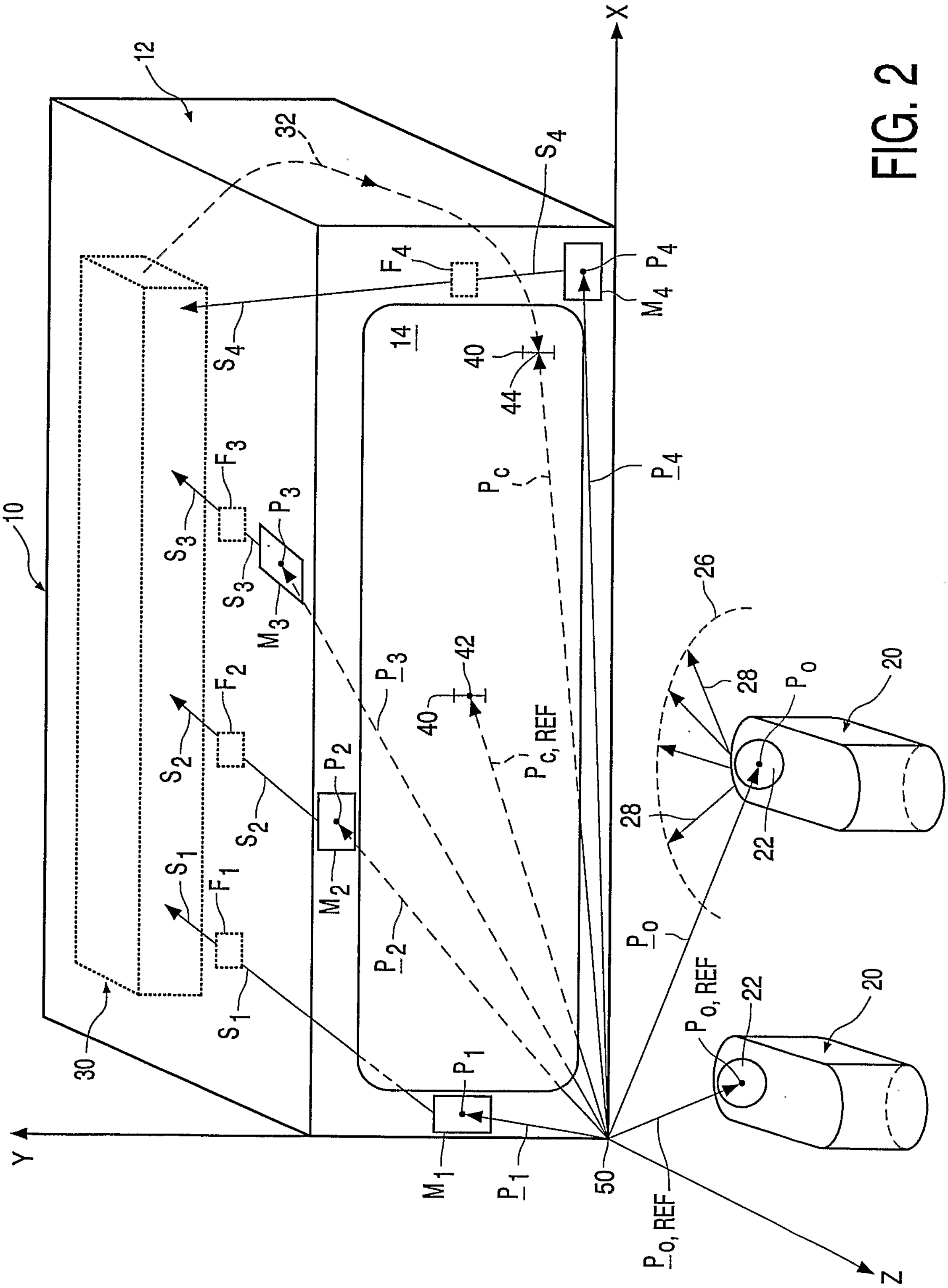
X
Y
Z
10
12
14
20
22
26
28
30
32
40
42
44
50
M_1
M_2
M_3
M_4
P_1
P_2
P_3
P_4
F_1
F_2
F_3
F_4
S_1
S_2
S_3
S_4
P_o
P_c
$P'_{c, REF}$
$P_{o, REF}$

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/01254

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K11/18

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)
IPC 7 G06K

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 654 648 A (BURGESS KEN L ET AL) 31 March 1987 (1987-03-31) column 11, line 55 - line 57 abstract; claim 1; figures 1,10	1-11
X	EP 0 718 792 A (LG ELECTRONICS INC) 26 June 1996 (1996-06-26) abstract; claim 1; figure 4	1-11
A	US 4 814 552 A (STEFIK MARK J ET AL) 21 March 1989 (1989-03-21) abstract; figure 1B	1-11
A	US 5 144 594 A (GILCHRIST IAN R) 1 September 1992 (1992-09-01) column 2, line 64 -column 3, line 22 abstract; claim 1; figure 5	1-11
	-/--	

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

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2003	02. 09. 2003

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	LISBETH ANDERSSON/JA A

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/IB 03/01254

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 5 691 959 A (CUMMINS JAMES D ET AL) 25 November 1997 (1997-11-25) column 6, line 29 - line 34 abstract; figure 7A -----	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 03/01254

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