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INPUTTING INFORMATION TO SYSTEMS INCLUDING A DISPLAY DEVICE

Field of the invention

The present invention relates to information display devices, and in particular to one arranged to operate in combination with a pointing device to permit a user to enter data by manipulating the pointing device.

Background of Invention

Several systems are known and in common use in which a user manipulates a pointing device (such as an elongate object) to input data into a computer system including a display device which generates an image in a display area.

One such common display device is a liquid crystal display (LCD) panel, and many known systems employ an array of sensors, such as pressure sensors, capacitive sensors or a conductive sensors, extending over the surface of the LCD panel. However, since the sensors have to be located in front of the display surface, they tend to deteriorate the display's transparency.

Furthermore, such solutions cannot be applied to other types of display device, such as display devices which project an image onto a screen. In such situations it is more usual for the position of the pointing device to be sensed by arranging for the pointing device to emit ultrasonic or radio wave signals (e.g. from the tip of the pointing device), and for these signal to be detected using ultrasonic sensors or radio wave sensors respectively. In such systems, the position of the pointing device is measured using triangulation. However, more than two transmitters or receivers are generally required, located around the screen. Furthermore, the measurement errors tend to be relatively large.

Summary of the Invention

The present invention seeks to provide a new and useful data input method and system, and in particular a method and system which do not affect the quality of the image and which can measure the location of the pointer
5 accurately.

In general terms, the invention proposes that the pointing device should include a sensor which is sensitive to a spot of light being generated at a location in the display area which depends on the position of the pointing
10 device. The spot of light is scanned over the display area, and the sensor generates a signal when that spot of light is at a location. The time at which the sensor senses the spot of light is thus indicative of the position of the device.

15 The spot of light may comprise light in the visible frequency range. Indeed, in certain embodiments it is light produced by the display device to display the image in the display area. Alternatively or additionally, the spot of light may be invisible light (e.g. infrared light), preferably unrelated to and uncorrelated with the image being displayed. Note that the term "light" is used in this document
20 to include electromagnetic radiation in all frequency ranges, but most particularly infrared and visible light.

Thus, the invention makes it possible to detect the position of the pointing device using no sensors except the sensor located in the pointing device.

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Furthermore, the position of the pointing device is located without the need to provide an array of sensors over the display, and thus without degrading or dimming the image displayed on the display device.

Furthermore, the present method is suitable for use when the display device is a projector which projects the image onto a screen.

5 The location of on the display area is typically selected using a stylus of the pointing device. In the case that the pointing device is elongate, its "stylus" is typically at one end of the pointing device. The pointing device may be designed to touch the display area with the stylus. Alternatively, the pointing device may be suitable for use without contact, e.g. if an axis of the elongate pointing device passing through the stylus intercepts the selected location on
10 the display area.

Specifically, one expression of the invention is an apparatus for displaying an image on a display area and determining the position of a pointing device in relation the display area, the apparatus comprising:

- 15 a raster scan generator which controls the movement of a spot of light to traverse the display area in a raster pattern,
- a photo-detector associated with a stylus of the pointing device, and for sensing when the spot of light coincides with a location of the display area selected by positioning the pointing device,
- 20 a comparison unit for obtaining a comparison signal indicative of the timing of a signal derived from the output of the photo-detector in relation to a reference signal indicating the timing of the raster scan, and
- a location estimator unit which uses the comparison signal to estimate the position of the stylus in relation to the display area.

25 Thus, a user is enabled to input data to the apparatus by manipulating the pointing device to select the location within the display area. The apparatus may comprise further computing devices (integrated with the display device or not) which employ the data for computing tasks.

Brief Description of The Figures

Preferred features of the invention will now be described, for the sake of illustration only, with reference to the following figures in which:

Fig. 1, which is composed of Fig. 1(a) and Fig. 1(b), is a schematic
5 view of a first embodiment of the invention;

Fig. 2 is a schematic view of a second embodiment of the invention which uses a cathode ray tube as a display device;

Fig. 3, which is composed of Figs. 3(a), 3(b) and 3(c), shows an
example of a peak detector apparatus suitable for use in an embodiment of
10 the invention, and the operation of this device in two different cases;

Fig. 4 shows another example of a peak detector apparatus suitable for use in an embodiment of the invention

Fig. 5 shows a raster scan and the period of time "t" measured in the
embodiments of the invention;

15 Fig. 6 shows a third embodiment of the invention which use a projector display; and

Fig. 7 shows an example of properties of optical filters suitable for use in the embodiment of Fig. 6.

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Detailed Description of the embodiments

Referring to Fig. 1(a), a first embodiment of the invention is shown which comprises a pointing device 1 and a display device 3. The display device 3
25 includes a display area 5 and a raster scan generator which generates a spot of light moving in a raster shape 7 within the display area 5. This spot of light may or may not be the same light which is used to generate an image in the display area of 5 (these two possibilities are described respectively below in the second and third embodiments of the invention).

The pointing device 1 comprises a photo-detector 11 at one end (the stylus), and a transmitter 8 which transmits signals wirelessly to an antenna 9 of the display device 3.

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Turning to Fig. 1(b) the internal structure of the pointing device 1 and the display device 3 are shown. The communication link between them produced by the antennas 8, 9 is indicated as 2. Note that in alternative embodiments this communications link 2 may be implemented using a wire.

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The pointing device 1 includes a peak detector 13 which generates a peak detection pulse when the light detected by the sensor 11 is at a peak with predefined characteristics (as described below). The detection pulse is transmitted to the display device 3 over the link 2. The peak detector 13 is designed so as to put the signal generated by the sensor 11 through a filter, and thereby find the signal for the light which composes the raster scan 7.

The display device 3 includes: a raster scan generator 31 which moves the spot of light over the display area 5 in the raster pattern 7; a reference pulse generator 33 which generates a reference pulse which is transmitted to the raster scan generator 31 to trigger the generation of the raster; a timer 35 which also receives the signal from the reference pulse generator 33 and outputs a time difference indication signal indicating the delay of the detection pulse after the reference pulse; and a location estimator 37 which estimates the position of the pointing device (that is, of the sensor 11) within the display area 5 using the time difference indication signal. The raster scan generator 31 may be of the form used to generate a raster display in a conventional display device, and the display device 3 may include all the other components (not shown) used to generate an image in the display area 5, such as a microprocessor which generates the content of the image. Note that the

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display device 3 may alternatively have an input which receives data defining which image it should display.

Note that the raster scan generator 31 may be part of the mechanism to
5 generate an image in the display area 5 composed of raster scans.

Alternatively, the raster scan generator 31 may generate a raster scan of invisible guide light to which the sensor 11 is sensitive overlaying the displayed image.

10 Since the reference pulse controls the timing of the raster scan generator 31, the reference pulse corresponds to a fixed point on the screen. In other words, the reference pulse is completely synchronized with corresponding frames of the image.

15 Figure 2 shows a second embodiment of the invention which utilizes a cathode ray tube (CRT) as a display device. Elements corresponding generally to those of the first embodiment are denoted by reference numerals 100 higher. In particular, the pointing device 101 may be identical to the pointing device 1 of Fig. 1, and includes a photo-detector at the tip of the
20 stylus. Preferably, a pressure sensor also provided there so that the stylus can sense both the brightness and the pressure with which the pointing device 101 is pressed against the display screen 105. The internal construction of the display device 103 may be as shown in Fig. 1(b), plus of course the components which are required to generate the CRT display.

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A first example of a peak detector 13 suitable for use in the embodiments of Figs. 1 and 2 is shown in Fig. 3(a). The unit 13 includes an inverter 41 which receives the reference pulse (which is passed to the device 1 via the link 2), and uses it as the CLR input to a D flip-flop 42. The D flip-flop 42 also
30 receives the output of the pressure sensing device as a pressure pulse which

is passed to the D input of flip-flop 42. The circuit further includes a comparator 43 which receives the output of the photo-detector 11 and compares it to a threshold set by a variable resistor 44 connected between earth and a known voltage. Thus the output of the flip-flop 42 is only high when the photodetector 11 has an output above the threshold defined by the resistor 44 at a time when the pressure pulse is high and the reference pulse is low. The output of the flip-flop 42 is passed to a second D flip-flop 45. The Q output of the second flip-flop 45 is passed to an AND gate 47, and also to the D input of a third D flip-flop 46. The second and third flip-flops 45, 46 are both controlled by a clock signal. The $\neg Q$ output of the third flip-flop 46 is the other input to the AND gate 47. The function of the flip-flops 45, 46 is to generate a signal corresponding to only the first rising edge of the photo-detector pulse after the reference pulse while the pressure pulse is high.

The timing of the signal at each point is illustrated in Fig. 3(b) and Fig. 3(b). These show respectively the cases in which the pressure pulse is shorter than the interval between reference pulses, and the case in which the pressure pulse is longer than the reference pulses. "D-FF1Q" means the output Q of the flip-flop 42 in fig. 3(a). The flip-flops 45, 46 co-operate to generate a short pulse corresponding to the rising edge of D-FF1 Q.

A second example of a peak detector suitable for use in the embodiments of Figs. 1 and 2 is shown in Fig. 4, which also shows how this unit 13 interacts with the timer 35. Elements of the unit 13 which correspond to those of Fig. 3(a) are shown by the same reference numerals. As indicated, the timer 35 in this case includes a timer unit 51 which is started by the reference pulse, stopped by the output of the unit 13, and which receives also the clock signal. Note that in this case the reference signal does not have to be sent though the link 2.

A measurement of the location of the stylus may be performed as follows in various embodiment of the invention. The raster image is generated by the CRT as shown in Fig. 5. When the user touches a certain point on the CRT screen with the stylus of the pointing device 101, the pressure sensor detects the pressure and generates a pressure pulse. If the photo-detector 11 senses the light of the raster scan while the pressure pulse is active, the peak detector 13 generates a peak detect pulse at the timing of the first sense of the raster-scanning beam. The timer 35 measures the time t which is the period between the reference pulse and the peak detect pulse.

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Let us suppose that, as shown in Fig. 5, the raster scan begins from the upper left corner, scans horizontally frequently and ends at the lower right corner. The frame rate and the resolution of the image are defined as F (Hz) and $R_v \times R_h$ (pixel), respectively, where R_v is the number of vertical pixels and R_h is the number of horizontal pixels. Let the time per pixel be P and the time per line of pixels be L . Thus, $L = 1/(F \times R_v)$ and $P = L/R_h = 1/(F \times R_v \times R_h)$. Under these conditions the location estimator 37 estimates the coordinates of the stylus location (x, y) following formulae (1) and (2):

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$$20 \quad x = (t \% L) / P = \{t \% (1 / (F \times R_v))\} \times F \times R_v \times R_h \quad (1)$$

$$y = [\{t - (t \% L)\} / L] + 1 = [t - \{t \% (1 / (F \times R_v))\}] \times F \times R_v + 1 \quad (2)$$

where the operation $(A \% B)$ denotes the residue of (A / B) .

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The estimated position of the stylus obtained by the location estimator 37 constitutes input data generated under the control of the user, and may be input to software run by the display device 3, 103 or alternatively transmitted out of the display device 3, 103, e.g. to another computing system. For example, the data generated by the location estimator 37 is suitable for interactive operation between a machine (e.g. the display device 3, or another

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device) and a user. For example, it can be used for selecting from a menu, answering questions, and so on.

Figure 6 shows a portion of a third embodiment of this invention. The pointing device of this system may be identical to that of Fig. 1. However, the display device in this case is an image projector unit. The projector unit projects an image on a screen. The projector unit has a general construction identical to that of the display device 3 of Fig. 1(b), and Fig. 5 shows the construction of the raster scan generator 231 (corresponding to the raster can generator 23 of Fig. 1(b).

The display device of Fig. 6 includes four separate sources of light. Three of these sources of light produce respectively a green light beam 1031, a red light beam 1032 and a blue light beam 1033. These pass through respective LCD panels 1034, 1035, 1036. When each of the beams of visible light is transmitted through the respective LCD panel, the intensity of the light beam is modulated pixel by pixel. The three beams are merged into a signal beam by a unit 1037, and pass through a first optical filter 1038, a half mirror 1039, and to a projection lens 1040, which focuses the modulated visible light to create an image on a screen (not shown). These features are known in conventional projection display devices.

In contrast to known projection devices, however, the display device of this embodiment has a further light source 1041 producing non-visible light, such as infrared light. This light source may be an infrared LED for example, which produces a beam of infrared light. The infrared light passes to a horizontal scanning mirror 1042, and then to a vertical scanning mirror 1043, so that a raster scan is produced. This scanning beam passes through a second optical filter 1044, and is overlaid on the visible light beams by the half-silvered mirror 1039. From there it is projected on the screen through the projection lens

1040. For example, the position referring light may scan as follows: starting scanning horizontally from the upper left corner of the displayed image; after the beam comes to the upper right corner of the displayed image, it returns to the left end and starts scanning again from just below the starting point of the
5 first horizontal scan. Thus the infrared light scans over whole of the displayed image.

The pointing device is designed such that its photodetector is sensitive to the infrared light, and again preferably includes a pressure sensor. When the
10 stylus points at a certain point on the screen and the infrared beam passes near that point, a peak detect pulse is generated by the peak detector shown in Fig. 3. Then the location of the tip of the stylus is estimated following the formula (1) and (2), in the same manner as the previous embodiment.

15 The optical filters 1038, 1044 are effective to reduce the position sensing error which occurs due to the light of the displayed image. Only the visible ray penetrates through the optical filter 1038 which is put into the light path between the LCD panels and the half mirror 1039. Better results should be obtained if the other optical filter 1044 which transmits only an infrared ray is
20 placed between the raster scan generator 231 and the half mirror 1039.

Optionally, another optical filter which has the same properties as optical filter 1044 may be provided in front of the photo-detector mounted on the tip of stylus of the pointing device, so the light which passes through the LCD
25 panels cannot be detected in error by the photo-detector. An example of the properties for the optical filters 1038, 1044 is shown in Fig. 7.

Many variations of the embodiments shown are possible within the scope of the invention. For example, whereas the embodiments described above
30 optionally include a pressure sensor, the pressure sensor may be replaced (or

supplemented) by a push button, e.g. on the side of the pointing device. This is particularly suitable in the case that the pointing device is not intended to physically contact the display area, which is particularly likely to be the case in systems such as the third embodiment in which the image is projected onto a display area which is a separate screen. In that case, the peak detector should be designed so that if a light of the scan is detected while the push button is depressed, the peak detector generates a peak detect pulse.

Furthermore, although in the embodiments described above the reference pulse generator, timer and location estimator are located within the display device and the pointing device comprising the peak detection unit, this is not absolutely essential for implementations of the invention. Rather the system may comprise one or more of additional computing units which are physically separate from the pointing device and the display device, and perform one of more of these functions.

Furthermore, although conveniently the photo-detector is located at the stylus, embodiments of the invention are possible in which the photo-detector is spaced from the stylus, but connected by an optical path which starts at or proximate the stylus and extends to the photo-detector (e.g. through an optical cable).

Furthermore, the invention may be used in a system in which the pointing device is spaced from the screen in use. Some such conventional pointing devices emit a light beam to indicate a portion of the screen, and this feature too may be present in the system of the present invention.

Claims

1. An apparatus for displaying an image on a display area and determining the position of a pointing device in relation the display area, the
5 apparatus comprising:
 - a raster scan generator which controls the movement of a spot of light to traverse the display area in a raster pattern,
 - a photo-detector associated with a stylus of the pointing device, and for sensing when the spot of light coincides with a location of the display area
10 selected by positioning the pointing device,
 - a comparison unit for obtaining a comparison signal indicative of the timing of a signal derived from the output of the photo-detector in relation to a reference signal indicating the timing of the raster scan, and
 - a location estimator unit which uses the comparison signal to estimate
15 the position of the stylus in relation to the display area.
2. An apparatus according to claim 1 in which the output of the photo-detector is passed to a peak detector unit which detects a maximum intensity of light in a certain period and transmits a peak detection pulse to the
20 comparison unit.
3. An apparatus according to claim 2 in which the comparison unit is a timer which measures a time between a peak of the reference signal and the peak detection pulse.
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4. An apparatus according to any preceding claim further comprising a reference pulse generator which generates said reference signal as a reference pulse, the reference pulse being transmitted to the location estimator unit and to the raster scan generator, the raster scan generator

employing the reference pulse to synchronize raster scans with the reference pulses.

- 5 5. An apparatus in which the spot of light is associated with the generation of the image in the display area.
6. An apparatus according to claim 5, wherein the raster scan generator is a cathode ray tube.
- 10 7. An apparatus according to any of claims 1 to 4 in which the spot of light is invisible light.
8. An apparatus according to any of claims 1 to 4 or 7, wherein the raster scan generator is a light source, a vertical scanner and a horizontal scanner.
- 15 9. An apparatus according to any preceding claim, wherein the pointing device has a sensor on the stylus so as to sense contact between the stylus and the display area.
- 20 10. An apparatus according to claim 9 in which the sensor is a pressure, capacitance or conductive sensor.
11. An apparatus according to any preceding claim, wherein the pointing stylus has a push button which is to be pushed when the user wants the
- 25 11. apparatus to recognize the location of the stylus.
12. An apparatus according to any preceding claim, wherein the pointing device includes a optical filter for filtering light before it reaches the photo-detector, the optical filter filtering out at least a component of light which is
- 30 12. part of the image.

13. An apparatus according to claim 12 when dependent on claim 7 in which the optical filter filters out visible light while transmitting light at a frequency included in the spot of light.
14. An apparatus according to any preceding claim in which the raster scan device is located in a display device which also generates the image in the display area.
15. An apparatus according to claim 14 in which the display area is an area of the display device.
16. An apparatus according to claim 14 in which the display area is a screen of a screen device separate from the display device.
17. A method for inputting data to a computer system,
the method comprising manipulating a pointing device to position a stylus of the pointing device in relation to an image displayed on a display area, the pointing device having a photo-detector associated with the stylus;
the method further comprising the following automatic steps:
controlling the movement of a spot of light to traverse the display area in a raster pattern,
using the photo-detector to sense when the spot of light coincides with a location of the display area selected by positioning the pointing device,
obtaining a comparison signal indicative of the timing of a signal derived from the output of the photo-detector in relation to a reference signal indicating the timing of the raster scan, and
using the comparison signal to estimate the position of stylus in relation to the display area.