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U.S. PATENT: *7,663,607*
ISSUE DATE: *February 16, 2010*

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(12) **United States Patent**
**Hotelling et al.**

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(54) **MULTIPOINT TOUCHSCREEN**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 754 days.

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***G06F 3/041*** (2006.01)

(52) **U.S. Cl.** .................... **345/173**; 345/174; 178/18.01

(58) **Field of Classification Search** ......... 345/173–179; 178/18.01–18.04
See application file for complete search history.

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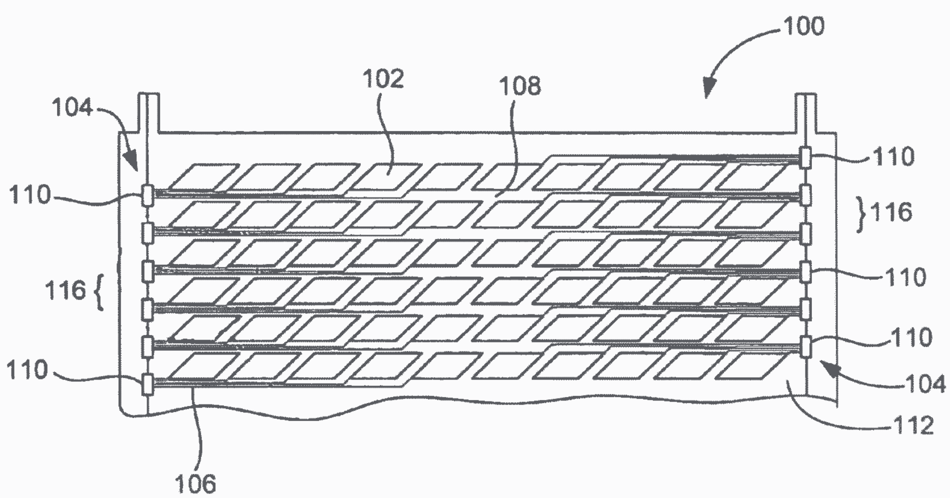
(57) **ABSTRACT**

A touch panel having a transparent capacitive sensing medium configured to detect multiple touches or near touches that occur at the same time and at distinct locations in the plane of the touch panel and to produce distinct signals representative of the location of the touches on the plane of the touch panel for each of the multiple touches is disclosed.

**11 Claims, 14 Drawing Sheets**



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# MULTIPOINT TOUCHSCREEN

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an electronic device having a touch screen. More particularly, the present invention relates to a touch screen capable of sensing multiple points at the same time.

2. Description of the Related Art

There exist today many styles of input devices for performing operations in a computer system. The operations generally correspond to moving a cursor and/or making selections on a display screen. By way of example, the input devices may include buttons or keys, mice, trackballs, touch pads, joy sticks, touch screens and the like. Touch screens, in particular, are becoming increasingly popular because of their ease and versatility of operation as well as to their declining price. Touch screens allow a user to make selections and move a cursor by simply touching the display screen via a finger or stylus. In general, the touch screen recognizes the touch and position of the touch on the display screen and the computer system interprets the touch and thereafter performs an action based on the touch event.

Touch screens typically include a touch panel, a controller and a software driver. The touch panel is a clear panel with a touch sensitive surface. The touch panel is positioned in front of a display screen so that the touch sensitive surface covers the viewable area of the display screen. The touch panel registers touch events and sends these signals to the controller. The controller processes these signals and sends the data to the computer system. The software driver translates the touch events into computer events.

There are several types of touch screen technologies including resistive, capacitive, infrared, surface acoustic wave, electromagnetic, near field imaging, etc. Each of these devices has advantages and disadvantages that are taken into account when designing or configuring a touch screen. In resistive technologies, the touch panel is coated with a thin metallic electrically conductive and resistive layer. When the panel is touched, the layers come into contact thereby closing a switch that registers the position of the touch event. This information is sent to the controller for further processing. In capacitive technologies, the touch panel is coated with a material that stores electrical charge. When the panel is touched, a small amount of charge is drawn to the point of contact. Circuits located at each corner of the panel measure the charge and send the information to the controller for processing.

In surface acoustic wave technologies, ultrasonic waves are sent horizontally and vertically over the touch screen panel as for example by transducers. When the panel is touched, the acoustic energy of the waves are absorbed. Sensors located across from the transducers detect this change and send the information to the controller for processing. In infrared technologies, light beams are sent horizontally and vertically over the touch panel as for example by light emitting diodes. When the panel is touched, some of the light beams emanating from the light emitting diodes are interrupted. Light detectors located across from the light emitting diodes detect this change and send this information to the controller for processing.

One problem found in all of these technologies is that they are only capable of reporting a single point even when multiple objects are placed on the sensing surface. That is, they lack the ability to track multiple points of contact simultaneously. In resistive and capacitive technologies, an average



of all simultaneously occurring touch points are determined and a single point which falls somewhere between the touch points is reported. In surface wave and infrared technologies, it is impossible to discern the exact position of multiple touch points that fall on the same horizontal or vertical lines due to masking. In either case, faulty results are generated.

These problems are particularly problematic in tablet PCs where one hand is used to hold the tablet and the other is used to generate touch events. For example, as shown in FIGS. **1**A and **1**B, holding a tablet **2** causes the thumb **3** to overlap the edge of the touch sensitive surface **4** of the touch screen **5**. As shown in FIG. **1**A, if the touch technology uses averaging, the technique used by resistive and capacitive panels, then a single point that falls somewhere between the thumb **3** of the left hand and the index finger **6** of the right hand would be reported. As shown in FIG. **1**B, if the technology uses projection scanning, the technique used by infra red and SAW panels, it is hard to discern the exact vertical position of the index finger **6** due to the large vertical component of the thumb **3**. The tablet **2** can only resolve the patches shown in gray. In essence, the thumb **3** masks out the vertical position of the index finger **6**.

## SUMMARY OF THE INVENTION

The invention relates, in one embodiment, to a touch panel having a transparent capacitive sensing medium configured to detect multiple touches or near touches that occur at the same time and at distinct locations in the plane of the touch panel and to produce distinct signals representative of the location of the touches on the plane of the touch panel for each of the multiple touches.

The invention relates, in another embodiment, to a display arrangement. The display arrangement includes a display having a screen for displaying a graphical user interface. The display arrangement further includes a transparent touch panel allowing the screen to be viewed therethrough and capable of recognizing multiple touch events that occur at different locations on the touch sensitive surface of the touch screen at the same time and to output this information to a host device.

The invention relates, in another embodiment, to a computer implemented method. The method includes receiving multiple touches on the surface of a transparent touch screen at the same time. The method also includes separately recognizing each of the multiple touches. The method further includes reporting touch data based on the recognized multiple touches.

The invention relates, in another embodiment, to a computer system. The computer system includes a processor configured to execute instructions and to carry out operations associated with the computer system. The computer also includes a display device that is operatively coupled to the processor. The computer system further includes a touch screen that is operatively coupled to the processor. The touch screen is a substantially transparent panel that is positioned in front of the display. The touch screen is configured to track multiple objects, which rest on, tap on or move across the touch screen at the same time. The touch screen includes a capacitive sensing device that is divided into several independent and spatially distinct sensing points that are positioned throughout the plane of the touch screen. Each sensing point is capable of generating a signal at the same time. The touch screen also includes a sensing circuit that acquires data from the sensing device and that supplies the acquired data to the processor.

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lines as for example ITO to provide the best possible index matching. As should be appreciated, the dummy features will more than likely still produce some gaps, but these gaps are much smaller than the gaps found between the lines (many orders of magnitude smaller). These gaps, therefore have minimal impact on the visual appearance. While this may be the case, index matching materials may be additionally applied to the gaps between the dummy features to further improve the visual appearance of the touch screen. The distribution, size, number, dimension, and shape of the dummy features may be widely varied.

FIG. **12** is a simplified diagram of a mutual capacitance circuit **220**, in accordance with one embodiment of the present invention. The mutual capacitance circuit **220** includes a driving line **222** and a sensing line **224** that are spatially separated thereby forming a capacitive coupling node **226**. The driving line **222** is electrically coupled to a voltage source **228**, and the sensing line **224** is electrically coupled to a capacitive sensing circuit **230**. The driving line **222** is configured to carry a current to the capacitive coupling node **226**, and the sensing line **224** is configured to carry a current to the capacitive sensing circuit **230**. When no object is present, the capacitive coupling at the node **226** stays fairly constant. When an object **232** such as a finger is placed proximate the node **226**, the capacitive coupling changes through the node **226** changes. The object **232** effectively shunts some of the field away so that the charge projected across the node **226** is less. The change in capacitive coupling changes the current that is carried by the sensing lines **224**. The capacitive sensing circuit **230** notes the current change and the position of the node **226** where the current change occurred and reports this information in a raw or in some processed form to a host controller. The capacitive sensing circuit does this for each node **226** at about the same time (as viewed by a user) so as to provide multipoint sensing.

The sensing line **224** may contain a filter **236** for eliminating parasitic capacitance **237**, which may for example be created by the large surface area of the row and column lines relative to the other lines and the system enclosure at ground potential. Generally speaking, the filter rejects stray capacitance effects so that a clean representation of the charge transferred across the node **226** is outputted (and not anything in addition to that). That is, the filter **236** produces an output that is not dependent on the parasitic capacitance, but rather on the capacitance at the node **226**. As a result, a more accurate output is produced.

FIG. **13** is a diagram of an inverting amplifier **240**, in accordance with one embodiment of the present invention. The inverting amplifier **240** may generally correspond to the filter **236** shown in FIG. **12**. As shown, the inverting amplifier includes a non inverting input that is held at a constant voltage (in this case ground), an inverting input that is coupled to the node and an output that is coupled to the capacitive sensing circuit **230**. The output is coupled back to the inverting input through a capacitor. During operation, the input from the node may be disturbed by stray capacitance effects, i.e., parasitic capacitance. If so, the inverting amplifier is configured to drive the input back to the same voltage that it had been previously before the stimulus. As such, the value of the parasitic capacitance doesn't matter.

FIG. **14** is a block diagram of a capacitive sensing circuit **260**, in accordance with one embodiment of the present invention. The capacitive sensing circuit **260** may for example correspond to the capacitive sensing circuits described in the previous figures. The capacitive sensing circuit **260** is configured to receive input data from a plurality of sensing points **262** (electrode, nodes, etc.), to process the data and to output processed data to a host controller.

The sensing circuit **260** includes a multiplexer **264** (MUX). The multiplexer **264** is a switch configured to perform time multiplexing. As shown, the MUX **264** includes a plurality of independent input channels **266** for receiving signals from each of the sensing points **262** at the same time. The MUX **264** stores all of the incoming signals at the same time, but sequentially releases them one at a time through an output channel **268**.

The sensing circuit **260** also includes an analog to digital converter **270** (ADC) operatively coupled to the MUX **264** through the output channel **268**. The ADC **270** is configured to digitize the incoming analog signals sequentially one at a time. That is, the ADC **270** converts each of the incoming analog signals into outgoing digital signals. The input to the ADC **270** generally corresponds to a voltage having a theoretically infinite number of values. The voltage varies according to the amount of capacitive coupling at each of the sensing points **262**. The output to the ADC **270**, on the other hand, has a defined number of states. The states generally have predictable exact voltages or currents.

The sensing circuit **260** also includes a digital signal processor **272** (DSP) operatively coupled to the ADC **270** through another channel **274**. The DSP **272** is a programmable computer processing unit that works to clarify or standardize the digital signals via high speed mathematical processing. The DSP **274** is capable of differentiating between human made signals, which have order, and noise, which is inherently chaotic. In most cases, the DSP performs filtering and conversion algorithms using the raw data. By way of example, the DSP may filter noise events from the raw data, calculate the touch boundaries for each touch that occurs on the touch screen at the same time, and thereafter determine the coordinates for each touch event. The coordinates of the touch events may then be reported to a host controller where they can be compared to previous coordinates of the touch events to determine what action to perform in the host device.

FIG. **15** is a flow diagram **280**, in accordance with one embodiment of the present invention. The method generally begins at block **282** where a plurality of sensing points are driven. For example, a voltage is applied to the electrodes in self capacitance touch screens or through driving lines in mutual capacitance touch screens. In the later, each driving line is driven separately. That is, the driving lines are driven one at a time thereby building up charge on all the intersecting sensing lines. Following block **282**, the process flow proceeds to block **284** where the outputs (voltage) from all the sensing points are read. This block may include multiplexing and digitizing the outputs. For example, in mutual capacitance touch screens, all the sensing points on one row are multiplexed and digitized and this is repeated until all the rows have been sampled. Following block **284**, the process flow proceeds to block **286** where an image or other form of data (signal or signals) of the touch screen plane at one moment in time can be produced and thereafter analyzed to determine where the objects are touching the touch screen. By way of example, the boundaries for each unique touch can be calculated, and thereafter the coordinates thereof can be found. Following block **286**, the process flow proceeds to block **288** where the current image or signal is compared to a past image or signal in order to determine a change in pressure, location, direction, speed and acceleration for each object on the plane of the touch screen. This information can be subsequently used to perform an action as for example moving a pointer or cursor or making a selection as indicated in block **290**.

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UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION



PATENT NO. : 7,663,607 B2
APPLICATION NO. : 10/840862
DATED : February 16, 2010
INVENTOR(S) : Hotelling et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1423 days.

Signed and Sealed this

Twenty-eighth Day of December, 2010

David J. Kappos

David J. Kappos
*Director of the United States Patent and Trademark Office*