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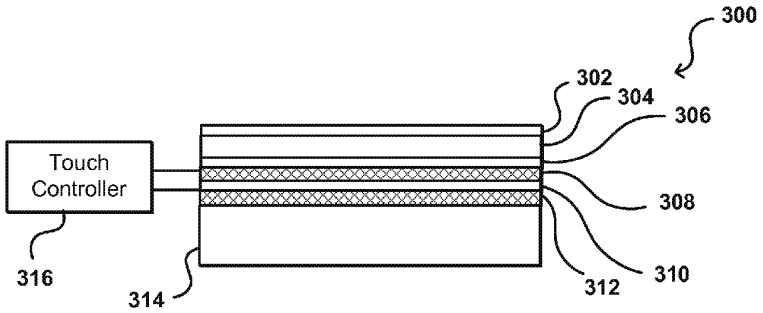


FIG. 3

(57) Abstract: A touch controller of a computing device can adjust various modes of operation of a touch panel in order to conserve resources on the device. The touch controller can dynamically adjust a rate at which touch sensors are scanned, or can scan touch sensors for the display panel using a different mode than for a single input button or other such element. The touch controller can also operate in a low power mode while the device is in standby, and then activate a high power mode of operation upon detecting an input such as a double tap. The touch controller can also alternate between low and high power modes of operation based at least in part upon a current application executing on the device.

# MULTIPLE TOUCH SENSING MODES

## CLAIM OF PRIORITY

**[0001]** This patent application claims priority to U.S. Provisional Patent Application No. 61/621,809 filed on April 9, 2012, entitled "HYBRID TOUCH SENSING MODES" which is incorporated by reference herein in its entirety.

## BACKGROUND

**[0002]** People are increasingly relying on computing devices, such as tablets and smart phones, which utilize touch sensitive displays. These displays enable users to enter text, select displayed items, or otherwise interact with the device by touching and performing various actions with respect to the display screen, as opposed to other conventional input methods. Devices are increasingly offering touch screens that can detect multiple touches, such as where a user uses more than two fingers to provide concurrent input. Such approaches typically consume a significant amount of power which is limited due to the battery capabilities of the device.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0003]** Various embodiments in accordance with the present disclosure will be described with reference to the drawings, in which:

**[0004]** FIG. 1 illustrates an example of a user providing a single touch input to a device in accordance with various embodiments.

**[0005]** FIG. 2 illustrates an example of a user providing a multi-touch input to a device in accordance with various embodiments.

**[0006]** FIG. 3 illustrates an example cross-section of a sensor array on a display element that can be utilized in accordance with various embodiments;

**[0007]** FIG. 4 illustrates an example of a portable computing device utilizing a grid of sensor lines that can be used to detect objects coming in contact with the touch screen display, in accordance with various embodiments;

**[0008]** FIG. 5 illustrates an example of a mutual capacitance screen being used in a proximity detection mode that is used to sense objects in proximity to the touch screen display, in accordance with various embodiments;

**[0009]** FIG 6 illustrates an example of a self-capacitance screen being used in a proximity detection mode that is used to sense objects in proximity to the touch screen, in accordance with various embodiments;

**[0010]** FIG. 7 illustrates an alternative example of a self-capacitance screen being used in proximity detection mode to sense objects in proximity to the touch screen, in accordance with various embodiments;

**[0011]** FIG. 8 illustrates an example of a process for operating a touch controller in multiple modes of detection, in accordance with various embodiments;

**[0012]** FIG. 9A illustrates an example of a process for adjusting a scan rate of a touch controller in accordance with various embodiments;

**[0013]** FIG. 9B illustrates an example of a process that can be used to operate the touch controller in a number of different sub-modes, in accordance with various embodiments;

**[0014]** FIG. 10 illustrates front and back views of an example portable computing device that can be used in accordance with various embodiments;

**[0015]** FIG. 11 illustrates an example set of basic components of a portable computing device, such as the device described with respect to FIG. 10; and

**[0016]** FIG. 12 illustrates an example of an environment for implementing aspects in accordance with various embodiments.

## DETAILED DESCRIPTION

**[0017]** In the following description, various embodiments will be illustrated by way of example and not by way of limitation in the figures of the accompanying drawings. References to various embodiments in this disclosure are not necessarily to the same

References to various embodiments in this disclosure are not necessarily to the same embodiment, and such references mean at least one. While specific implementations and other details are discussed, it is to be understood that this is done for illustrative purposes only. A person skilled in the relevant art will recognize that other components and configurations may be used without departing from the scope and spirit of the claimed subject matter.

**[0018]** Systems and methods in accordance with various embodiments of the present disclosure may overcome one or more of the aforementioned and other deficiencies experienced in conventional approaches to providing input to, or determining information for, a computing device. In particular, various approaches discussed herein enable a touch sensitive display or other such element to operate in different modes at different times, in order to attempt to conserve power during time periods when certain functionality is not needed. In addition, various approaches described herein use a number of electric field and capacity sensing techniques that enable the computing device to detect objects (e.g., a human finger) coming within proximity of the touch sensitive display before the objects make any physical contact with the computing device.

**[0019]** In accordance with an embodiment, a computing device (e.g., mobile phone, electronic reader or tablet computer) is described that includes a touch screen display and input assembly capable of detecting objects (e.g., human finger) in proximity of the touch screen or in physical contact with the touch screen. The touch screen includes a sensor layer (or several sensor layers) configured to detect changes in capacitance or changes in electric field caused by the objects in proximity of the display screen. The device further includes a touch controller, such as a low power microcontroller dedicated to sensing touches and/or objects. The touch controller is configured to analyze the changes in capacitance and/or electric field in order to detect the presence and location of objects in proximity of the display screen.

**[0020]** In accordance with an embodiment, the touch controller is capable of operating in at least two modes of operation. The first mode, an “active” or “high-power” mode, can utilize mutual capacitive touch sensing that enables tracking of multiple finger touches and gestures. The second mode, an “idle” or “low-power” mode can instead utilize self-capacitance touch sensing. This low-power mode can be utilized

when single touch input will likely be utilized, and in some cases, can be used to bring the device back from a standby or similar mode into a high power mode where mutual capacitive sensing is used, in order to allow for multi-touch input. For example, when the computing device is in in the "idle" mode, the touch controller can operate in self-capacitance mode to save on battery power. If the touch controller detects a specified event or interaction of objects with the display screen (e.g., a user double tapping the display screen), the device can switch to begin scanning in "high-powered" mutual capacitance mode, where multi-touch events are more accurately detected. The self-capacitance mode and the mutual capacitance mode will be described in further detail later in this disclosure.

**[0021]** In accordance with some embodiments, the touch controller is further capable of adjusting the scan rate used to scan the sensors of the display screen. For example, when the device is in the low-power or idle mode, or when the device is executing applications that are not capable of using multi-touch input, the touch controller may reduce the scan rate of the sensors in order to reduce power usage of the device. Similarly, when the device is awakened or when the application executing on the device is capable of utilizing multi-touch sensing, the scan rate can be increased to improve the accuracy of detecting multiple touch events. The adjusting of scan rates can be performed in the context of both the mutual capacitance mode and the self-capacitance mode of operation.

**[0022]** In accordance with some embodiments, the touch screen further provides a "proximity detection" or "hover detection" mode that is capable of sensing objects that are in the proximity of the display screen but which have not made physical contact with any part of the display screen. A number of different approaches are described herein for enabling the proximity detection mode, in the context of both mutual capacitance mode of operation and self-capacitance mode of operation.

**[0023]** FIG. 1 illustrates an example situation 100 wherein a user is holding a portable computing device 102 in the user's hand 104. The computing device 102 can be any appropriate device, such as a smart phone, tablet computer, or personal data assistant, among other such options. The computing device 102 has a capacitive touch screen 106 that can detect when a portion of a user's hand 104, such as a tip of a user's finger or thumb, comes in contact with the touch screen (or at least within a detectable

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