# CAPACITIVE KEYBOARD WITH POSITION DEPENDENT REDUCED KEYING AMBIGUITY

## BACKGROUND OF THE INVENTION

[0001] The invention relates to touch sensitive user interfaces having an array of sensing elements and methods for determining which of a plurality of sensing elements in simultaneous detection is intended by a user for selection. Thus the invention relates to a method and apparatus for controlling touch sensitive user interfaces, e.g. to assist in preventing accidental false inputs from keys adjacent to a selected key in a capacitive keyboard.

[0002] The use of capacitive proximity sensors, for example as keys in a keypad, is becoming more common. Capacitive sensors are frequently preferred to mechanical switches for a number of reasons. For example, capacitive sensors require no moving parts and so are less prone to wear than their mechanical counterparts. Capacitive sensors can also be made in relatively small sizes so that correspondingly small, and tightly packed keypad arrays can be provided. Furthermore, capacitive sensors can be provided beneath an environmentally sealed outer surface. This makes their use in wet environments, or where there is a danger of dirt or fluids entering a device being controlled attractive. Furthermore still, manufacturers often prefer to employ interfaces based on capacitive sensors in their products because such interfaces are often considered by users to be more aesthetically pleasing than conventional mechanical input mechanisms (e.g. push-buttons).

[0003] However, a drawback of interfaces based on arrays of capacitive sensors is that an object to be sensed, e.g. a user's pointing finger, will often be capacitively coupled to multiple capacitive sensors at the same time. This means that multiple capacitive sensors can appear to be activated simultaneously which can lead to an ambiguity as to which capacitive sensor in the array is intended for selection. This problem can be particularly apparent for sensors arranged into a closely packed array, e.g. in a keypad for a cellular telephone. With a small keypad such a this, a user's finger is likely to overlap multiple keys at the same time, i.e. both an intended key for selection, and also keys adjacent to it. This can be especially problematic if the user has large fingers, or if he presses on a panel over the sensors with enough force to deform his or her finger and so increase the effective area of his finger tip. The same sort of effect is found when a conducting film is spilled on a keyboard, in which case the user's finger is sensed as though it were the size of the puddle. Problems of this sort are particularly acute in cash register keyboards used in food service establishments where beverage and food sauce spills are a frequent occurrence. Another problem with capacitive keypads, known as the "handshadow" effect, arises because of the capacitive response to a body other than the pointing body, e.g., sensing the user's hand in addition to sensing his or her pointing finger.

[0004] U.S. Pat. No. 5,730,165 teaches a capacitive field sensor employing a single coupling plate and a method of detecting a change in capacitance of the coupling plate, $C_x$, to ground. The apparatus taught in U.S. Pat. No. 5,730,165 comprises pulse circuitry for charging the coupling plate and for subsequently transferring the charge from the plate into a charge detector, which may be a sampling capacitor, $C_s$. The transferring operation is carried out by means of a transfer switch electrically connected between the coupling plate and the charge detector. The disclosure of U.S. Pat. No. 5,730,165 is herein incorporated by reference.

[0005] U.S. Pat. No. 6,466,036 teaches pulse circuitry for measuring capacitance to ground, the circuitry comprising a plurality of electrical switching elements, each of which has one side electrically connected to either a power supply voltage or to a circuit ground point. This circuit arrangement, which may be used with a keyboard as well as for many other applications, is more compatible with available integrated circuit design and manufacturing practices than is prior art pulse circuitry, which commonly had one side of at least one switching element floating. These improved arrangements thereby provide superior performance at a lower manufacturing cost. The disclosure of U.S. Pat. No. 6,466,036 is herein incorporated by reference.

[0006] Attempts made to address the above-described problem of keying ambiguity with capacitive sensors are described in U.S. Pat. No. 6,993,607 and U.S. Ser. No. 11/402,269 (published as US 2006/0192690 A1). The disclosures of U.S. Pat. No. 6,993,607 and U.S. Ser. No. 11/279,402 are herein incorporated by reference.

[0007] U.S. Pat. No. 6,993,607 describes a method and apparatus for reducing keying ambiguity on a keyboard having an array of proximity sensors. The ambiguity is reduced by an iterative technique of repeatedly measuring a detected signal strength associated with each key in the array having respective output signals responsive to a degree of coupling between the key and a user, comparing all of the measured signal strengths to find a maximum, determining that the key having the maximum signal strength is the unique user-selected key, and maintaining the user selected key until the signal from that key falls below a threshold value. The signals from all the other keys are suppressed or ignored during the maintaining step.

[0008] U.S. Ser. No. 11/402,269 (published as US 2006-0192690 A1) describes an iterative method and apparatus for removing keying ambiguity on a keyboard by measuring a detected signal strength associated with each key in an array, comparing the measured signal strengths to find a maximum, determining that the key having the maximum signal strength is the unique user-selected first key, and maintaining that selection until either the first key's signal strength drops below some threshold level or a second key's signal strength exceeds the first key's signal strength. When any key is selected its signal strength value may be enhanced relative to all the other keys so as to deselect all other keys.

## SUMMARY OF THE INVENTION

[0009] According to a first aspect of the invention there is provided a touch-sensitive user interface, comprising: a plurality of sensing areas arranged within a sensing region, each sensing area having a position within the sensing region; a measurement circuit coupled to the sensing areas and operable to generate output signals responsive to a coupling between a pointing object and respective ones of the sensing areas; and a controller operable to receive the output signals from the measurement circuit and to determine a selected one of the sensing areas by taking account of both the output signals associated with the sensing areas and the positions of the sensing areas within the sensing region.