

Method Of Scanning an Array of Sensors

FIELD OF INVENTION

The invention relates broadly to a method of scanning an array of sensors, and to an array of sensors.

BACKGROUND

"Ghost Keys" is a problem of inaccurately detecting the actual location of contact with a contact-sensitive surface. For instance, the problem of "Ghost Keys" occurs when a location X on a contact-sensitive surface is the actual location of contact with the contact-sensitive area and yet other locations different from location X are determined to have been contacted on the contact-surface area.

Hence, there exists a need for a method and system which seek to address the problem of "ghosting" for better accuracy.

SUMMARY

In accordance with a first aspect of the present invention there is provided a method of scanning an array of sensors, the method comprises the steps of scanning a first set of sensing lines, wherein a sensing line of the first set is coupled with a plurality of sensors in an x-axis direction of the array; scanning a second set of sensing lines, wherein a sensing line of the second set is coupled with a plurality of sensors in a y-axis direction of the array; scanning a third set of sensing lines, wherein a sensing line of the third set is coupled with a plurality of sensors in a third direction of the array different from the x-axis and y-axis direction; generating a list of possible candidates of actuated sensors based on scan values of the first, second and third scanning lines; and determining a location of the sensor that has been actuated, wherein the determining step comprises eliminating at least one of the candidates based on a comparison with valid combinations of scan values for the first, second, and third scanning lines.

The sensing line of the third set may comprise sensors of the array which do not share sensing lines of the first and the second set.

The method may further comprise scanning an n th set of sensing line, $n=\{4, 5, \dots\}$, a sensing line of the n th set of sensing lines is coupled with a plurality of sensors of the array along an n th direction of the array.

The sensing line of the n th set may comprise sensors of the array which do not share sensing lines of the first to $(n-1)$ th set.

The sensors may comprise capacitive sensors.

The sensors may comprise mechanical switch type keys.

In accordance with a second aspect of the present invention there is provided an array of sensors comprising a first set of sensing lines, wherein a sensing line of the first set comprises a plurality of sensors of the array along a first direction of the array; a second set of sensing lines, wherein a sensing line of the second set comprises a plurality of sensors of the array along a second direction of the array; a third set of sensing lines, wherein a sensing line of the third set comprises a plurality of the sensors of the array along a third direction of the array; a sensor circuit coupled to the first, second and third set of sensing lines configured to determine accurately whether a sensor has been detected, wherein the sensor circuit comprises: a plurality of controller pins coupled to the first, second and third set of sensing lines; a line decoder unit coupled to the plurality of controller pins, wherein the line decoder is configured to determine actuated sensors of at least one sensor in the array of sensors; a candidate generator unit coupled to the line decoder configured to generate a list of possible candidates of actuated sensors based on scan values of the first, second and third scanning lines; and a validity checker unit coupled to the candidate generator unit configured to eliminate at least one of the candidates based on a comparison with valid

combinations of scan values for the first, second, and third scanning lines, wherein the validity checker unit is capable of outputting an output signal including the actuated sensors.

Each sensing line of the third set may comprise sensors of the array which do not share sensing lines of the first and the second set.

The sensing line of the n th set of sensing lines may comprise a plurality of sensors of the array along an n th direction of the array, for determining a location of the sensor that has been actuated.

Each sensing line of the n th set may comprise sensors of the array which do not share sensing lines of the first to $(n-1)$ th set.

The sensors may comprise capacitive sensors.

The sensors may comprise mechanical switch type keys.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

10 Figure 1 is a schematic diagram illustrating a scanning architecture for an array of sensors with a 3rd axis of scanning according to an example embodiment.

Figure 2 is a flowchart illustrating an algorithm used by a capacitive sensor circuit to determine the validity of keys in an example embodiment.

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Figure 3 is a schematic diagram illustrating the capacitive sensor circuit according to an example embodiment.

Figure 4 shows a flowchart illustrating a method of scanning an array of sensors.

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DETAILED DESCRIPTION

25 The example embodiments describe a method and a system having additional sensing lines, in part to resolve the problem of "ghost" keys in capacitive matrix scanning. In the example embodiment, three sets of sensing lines can be incorporated into the sensing area for ghost-free detection of up to two keys. Further in other embodiments, n sets of sensing lines can be incorporated into the sensing area for ghost free detection of up to $n-1$ keys.

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Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within an electronic storage device. These algorithmic descriptions and functional or symbolic representations are the means to convey effectively the substance of a body of work. An algorithm is here, and generally, conceived to be a self-

consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

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Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “processing”, “calculating”, “determining”, “generating”, “outputting”, or the like, refer to the actions and processes of an electronic system such as a computing system or
10 similar electronic device, that manipulates and transforms data represented as physical quantities within the electronic system into other data similarly represented as physical quantities within the electronic system or other information storage, transmission or display devices.

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An embodiment of a scanning architecture for an array of sensors is shown in Figure 1. For example, Figure 1 shows a key array with three sets of scanning lines 120, 122 and 124. The example embodiment comprises of a sensing area 102 having 25
20 keys or sensors 101 arranged in a 5 x 5 array. The sensors can be capacitive sensors. The sensors 101 in the sensing area 102 are connected to a sensor circuit 100, such as a capacitive sensor circuit, via the three sets of sensing lines 120, 122 and 124. The sensor circuit 100 can determine which keys have been touched based on the signals transmitted by sensing lines 120, 122 and 124.

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In the example embodiment, the three sets of sensing lines 120, 122 and 124 provide signals to the sensor circuit 100 such that the sensor circuit 100 can determine the exact contact location or locations on the contact-sensitive surface area or the sensing area 102. For instance, when keys or sensors 104 and 106 are touched, sensor lines 108, 110 and 112, 114 of the first and second sets of sensing lines 120 and 122 respectively relay a signal such as an increased capacitance to the sensor
30 circuit 100. In addition, sensor line 116 of the third set of the sensing lines 124 also relays a signal such as an increased capacitance, to the sensor circuit 100.

In the example embodiment, the sensor circuit 100 scans the sensing area 102 via received signals on the three sets of sensing lines 120, 122, 124, and

processes this information. The sensor circuit 100 determines which sensors or keys having been actuated by means of an example algorithm as shown in Figure 2. In the algorithm, the sensor circuit reads all sets of sensor lines 120, 122, 124, either individually, together or in any combination (steps 202, 204, and 206). The algorithm
5 identifies the sensing lines which have been activated by means of having a change in signal output such as having an increased capacitance (step 208). The sensors or keys that are coupled with an active sensing line from the three sets of sensing lines are identified and determined as keys that have been actuated (step 210).

10 Returning to Figure 1, the present specification of the sensor circuit 100 discloses an apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a general purpose computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not
15 inherently related to any particular computer or other apparatus. Various general purpose machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate.

20 The example embodiment of the sensor circuit 100 may also be implemented as one or more hardware modules. More particular, in the hardware sense, a module is a functional hardware unit designed for use with other components or modules. For example, a module may be implemented using discrete electronic components, or it can form a portion of an entire electronic circuit such as an Application Specific Integrated
25 Circuit (ASIC). Numerous other possibilities exist. Those skilled in the art will appreciate that the system can also be implemented as a combination of hardware and software modules.

30 In the example embodiment, the sensor circuit 100 determines that only keys or sensors 104 and 106 are actuated because only keys or sensors 104 and 106 are coupled with activated sensing lines on the first, second and third set of sensing lines 120, 122 and 124.

The number of sensing lines in the sensing area is related to the number of control pins with respect to the sensor circuit 100. For instance, a X by Y array of capacitive keys or sensors can have the following number of controller pin-count:

$$5 \quad \text{Controller Pin-Count} = (X + Y) + \text{Max}(X, Y)$$

In one example, an 8 x 8 sensing area can require

$$(8 + 8) + \text{Max}(8, 8) = 24$$

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controller pins

In another embodiment of the present invention, additional sets of sensing lines can be incorporated into the sensing area. For example, a 4th set of sensing lines could also be implemented for detecting accurate actuation of 3 keys or sensors. Thus, for the detection of the actuation of up to $(n-1)$ keys, n sets of sensing lines can be used. Each sensing line of the n th set comprises keys of the array which do not share sensing lines of the first 1 to $(n-1)$ th set. For each additional set of sensing line, N , beyond the x and y-axis, the controller pin-count will be:

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$$\text{Controller Pin-Count} = (X + Y) + N * \text{Max}(X, Y)$$

in the example embodiment. Therefore, in the example embodiment, to achieve ghost-free detection of up to 3 keys on an 8 x 8 sensing area, the controller pin count could be

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$$(8 + 8) + 2 * (8) = 32$$

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pins.

Figure 3 is a schematic diagram illustrating the capacitive sensor circuit 300 in an example embodiment. 15 sensing lines 302 to 330 are input into the capacitive sensor circuit 300 at respective controller pins e.g. 331 and fed into a line decoder

332. The 15 sensing lines 302 to 330 are comprised of three different sets of five sensing lines, each set comprising sensing lines from an axis of scanning. The line decoder 332 decodes capacitive changes in the sensing lines in each of the three sets to determine which sensing lines have been activated. The sensing lines decoded as activated 334 are sent to a candidate generator 336 which generates a list of possible candidates of actuated keys or sensors 338. Each candidate comprises one activated sensing line from each of the three different sets. Candidates are generated until all possible combinations are exhausted to form the list of possible candidates 338.

For example, referring to Figure 1, assuming keys 104 and 106 were actuated, sensing lines X3, X5, Y1, Y3 and Z5 will be decoded by the line decoder 332 as activated. Using this information, the candidate generator 336 generates the list of possible candidates of actuated keys or sensors 338, namely:

1. (X3, Y1); Z5
2. (X3, Y3); Z5
3. (X5, Y1); Z5
4. (X5, Y3); Z5.

The candidates are represented as an (X, Y) coordinate set based on the X and Y axis of scanning and a further check value based on the Z axis of scanning. Also, it is observed that four candidates are generated despite only two keys or sensors being actuated. Candidates 1 and 4 (corresponding to sensors 126 and 128 respectively) are "ghost keys" which should be eliminated. The four candidates are sent to a validity checker 340 of Figure 3, which verifies the validity of the candidates by means of a look up table. The look up table will reveal that (X3, Y1) of candidate 1 corresponds with a check value Z3 instead of Z5. Therefore, candidate 1 will be deemed invalid and discarded. Similarly, because (X5, Y3) corresponds with the check value Z3 instead of Z5, candidate 4 is discarded. Finally, the validity checker 340 outputs the remaining candidates comprising of candidate 2 (X3, Y3) and candidate 3 (X5, Y1) as the actuated keys or sensors 342. It will be appreciated by a person skilled in the art that should additional dimensions of scanning be used for ghost free detection of three or more keys, there will be additional check values for validating the generated candidates.

Figure 4 shows a flowchart 400 illustrating a method of scanning an array of sensors. At step 402, a first set of sensing lines is scanned, wherein a sensing line of the first set is coupled with a plurality of keys or sensors of the array along a first direction of the array. At step 404, a second set of sensing lines is scanned, wherein a sensing line of the second set is coupled with a plurality of keys or sensors of the array along a second direction of the array. At step 406, a third set of sensing lines is scanned, wherein a sensing line of the third set is coupled with a plurality of the keys or sensors along a third direction of the array. At step 408, the location of the keys or sensors on the sensing area which have been actuated are determined.

The example embodiment may also be extended to mechanical switches where the keys or sensors as described comprise of mechanical switch type keys. It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A method of scanning an array of sensors, comprising the steps of:
 scanning a first set of sensing lines, wherein a sensing line of the first set
 5 is coupled with a plurality of sensors in an x-axis direction of the array;

scanning a second set of sensing lines, wherein a sensing line of the
 second set is coupled with a plurality of sensors in a y-axis direction of the array;

scanning a third set of sensing lines, wherein a sensing line of the third
 set is coupled with a plurality of sensors in a third direction of the array different
 10 from the x-axis and y-axis direction;

generating a list of possible candidates of actuated sensors based on
 scan values of the first, second and third scanning lines; and

determining a location of the sensor that has been actuated, wherein the
 determining step comprises eliminating at least one of the candidates based on a
 15 comparison with valid combinations of scan values for the first, second, and third
 scanning lines.

2. The method of claim 1, wherein the sensing line of the third set
 comprises sensors of the array which do not share sensing lines of the first and
 20 the second set.

3. The method of claim 1, further comprising scanning an n th set of
 sensing line, $n=\{4, 5, \dots\}$, a sensing line of the n th set of sensing lines is coupled
 with a plurality of sensors of the array along an n th direction of the array.
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4. The method of claim 1, further comprises the steps of: scanning a
 fourth set of sensing line, wherein a sensing line of the fourth set of sensing lines
 of the first to third set.

30 5. The method of claim 1, wherein the sensors comprise capacitive
 sensors.

6. The method of claim 1, wherein the sensors comprise mechanical
 switch type keys.
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7. An array of sensors, comprising:

a first set of sensing lines, wherein a sensing line of the first set comprises a plurality of sensors of the array along a first direction of the array;

a second set of sensing lines, wherein a sensing line of the second set comprises a plurality of sensors of the array along a second direction of the array;

a third set of sensing lines, wherein a sensing line of the third set comprises a plurality of the sensors of the array along a third direction of the array;

a sensor circuit coupled to the first, second and third set of sensing lines configured to determine accurately whether a sensor has been detected, wherein the sensor circuit comprises:

a plurality of controller pins coupled to the first, second and third set of sensing lines;

a line decoder unit coupled to the plurality of controller pins, wherein the line decoder is configured to determine actuated sensors of at least one sensor in the array of sensors;

a candidate generator unit coupled to the line decoder configured to generate a list of possible candidates of actuated sensors based on scan values of the first, second and third scanning lines; and

a validity checker unit coupled to the candidate generator unit configured to eliminate at least one of the candidates based on a comparison with valid combinations of scan values for the first, second, and third scanning lines, wherein the validity checker unit is capable of outputting an output signal including the actuated sensors.

8. The array of claim 7, wherein the sensing line of the third set comprises sensors of the array which do not share sensing lines of the first and the second set.

9. The array of claim 7, wherein the sensors comprise capacitive sensors.

10. The array of claim 7, wherein the sensors comprise mechanical switch type keys.