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US 20080316184 A1

(58) Field of Search:
INT CL **G06F**

(54) Title of the Invention: **Keyboard**
Abstract Title: **Keyboard calibration**

(57) A method of associating calibration information with a keyboard comprising a touch sensor, comprises determining calibration information for a further keyboard comprising a similar touch sensor, and associating the calibration information with the keyboard. The method may comprise determining calibration information for a plurality of further keyboards comprising similar touch sensors, combining this calibration information, and associating the combined calibration information with the keyboard. The keyboard and the further keyboard may comprise the same types of components, for example the same types of protective plate, with each plate being associated with a corresponding touch sensor, and/or the keyboard and the further keyboard may be from the same product series. The method may comprise determining a variation between the keyboard and the further keyboard, determining modified calibration information based on the calibration information and the variation, and associating the modified calibration information with the keyboard, for example with a difference in componentry between the keyboard and the further keyboard.

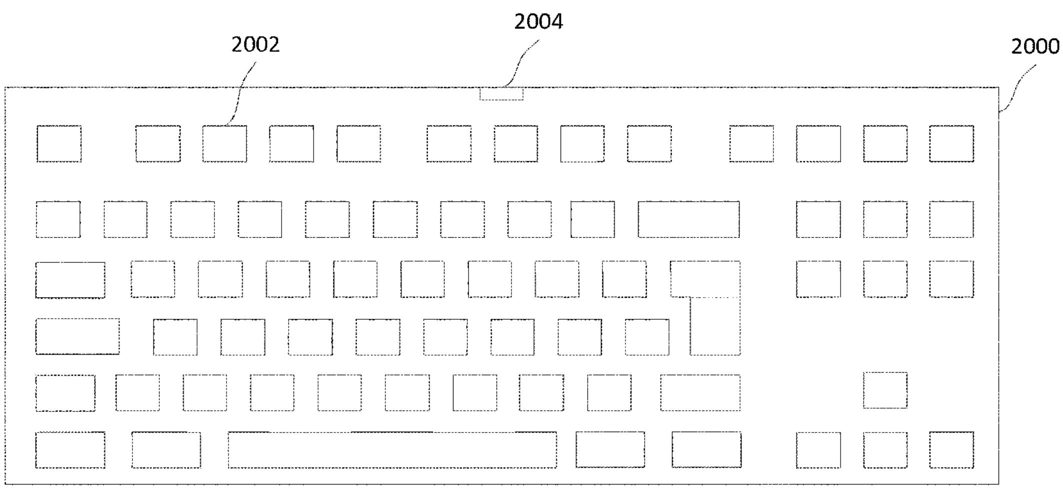

Figure 2

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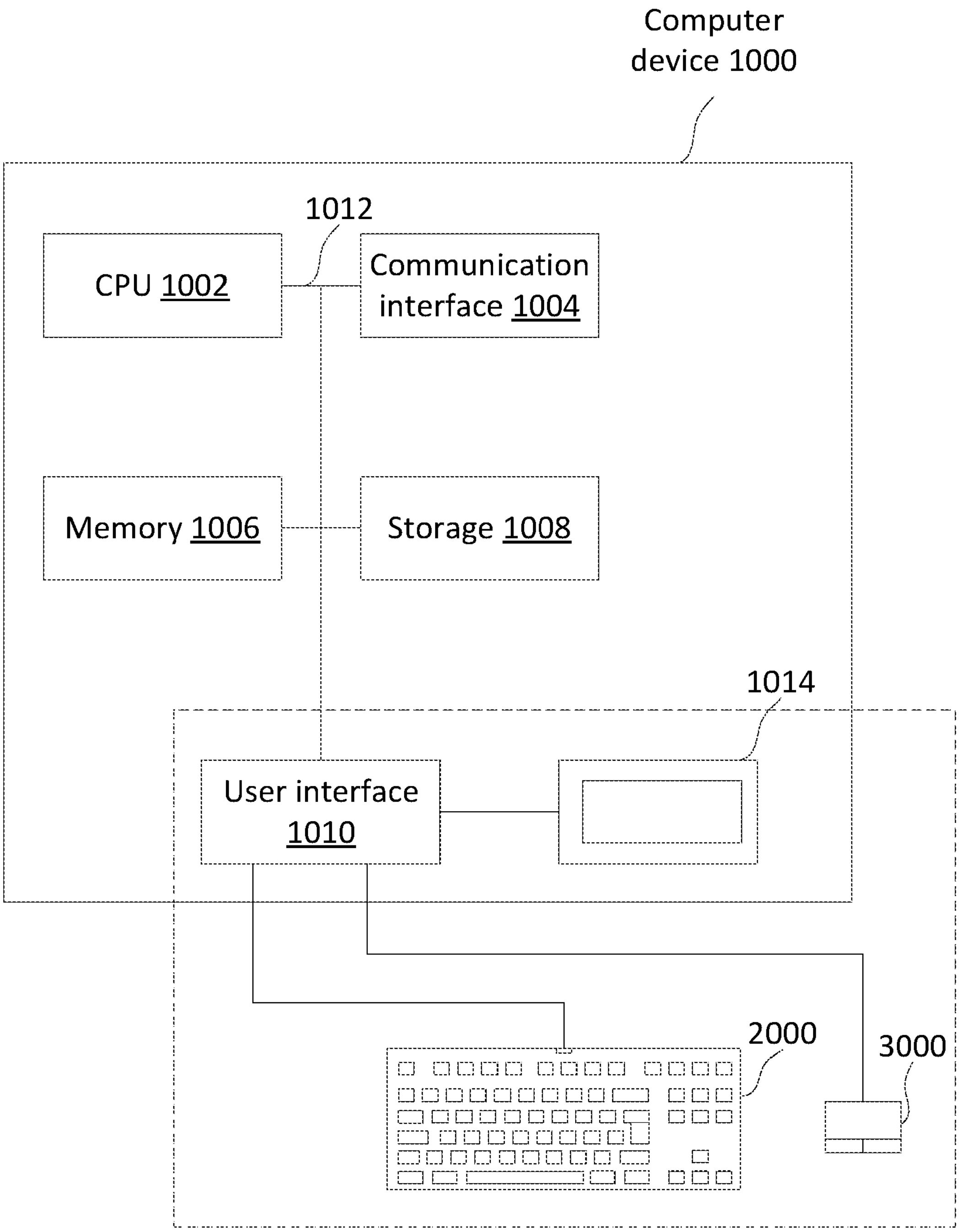

Computer
device 1000
1012
CPU 1002
Communication
interface 1004
Memory 1006
Storage 1008
1014
User interface
1010
2000
3000

Figure 1

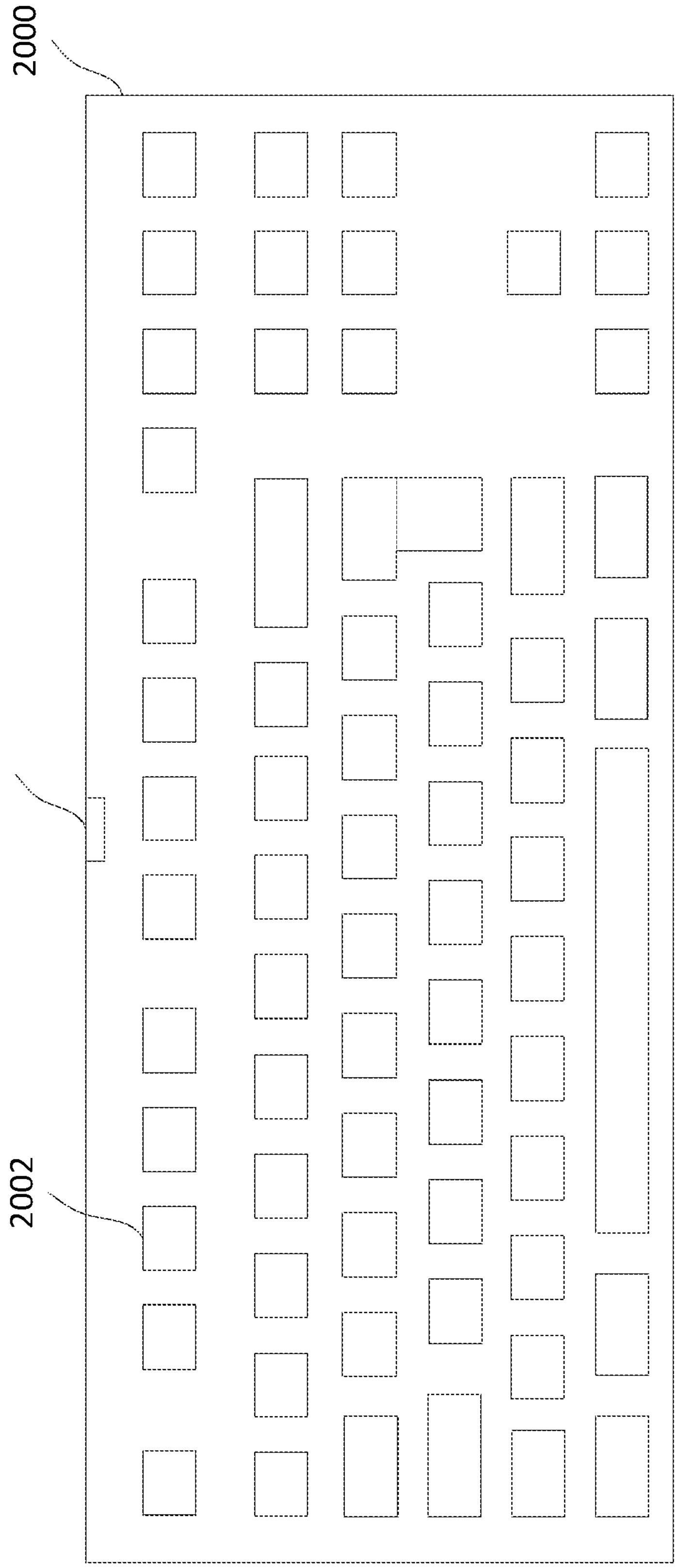


Figure 2

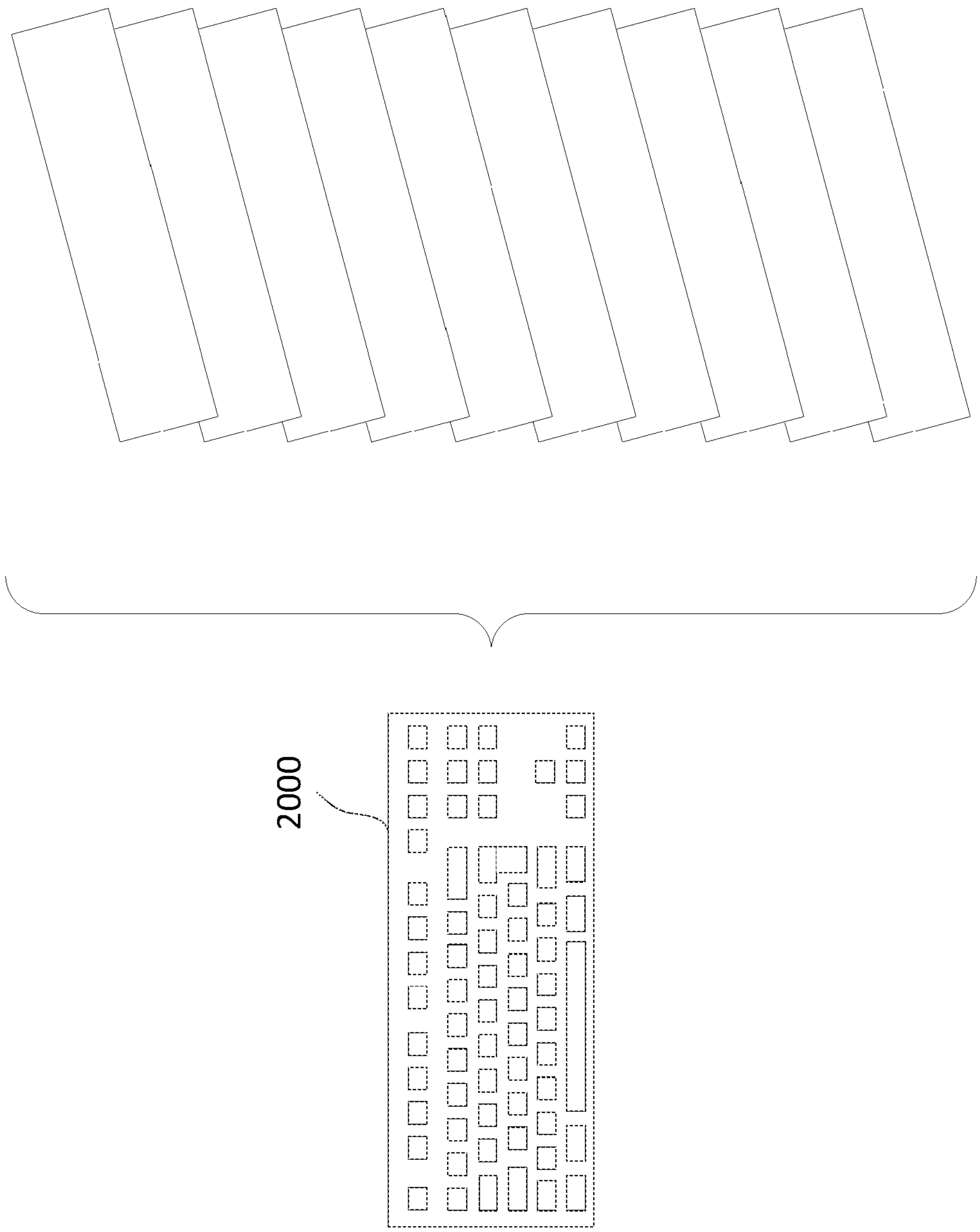


Figure 3

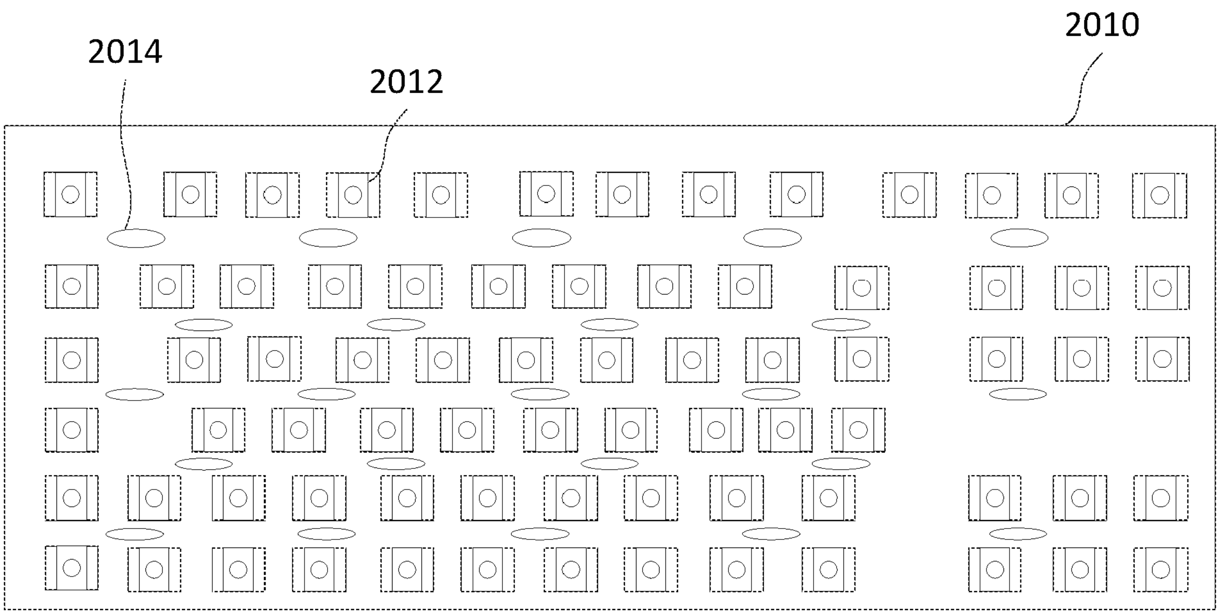


Figure 4

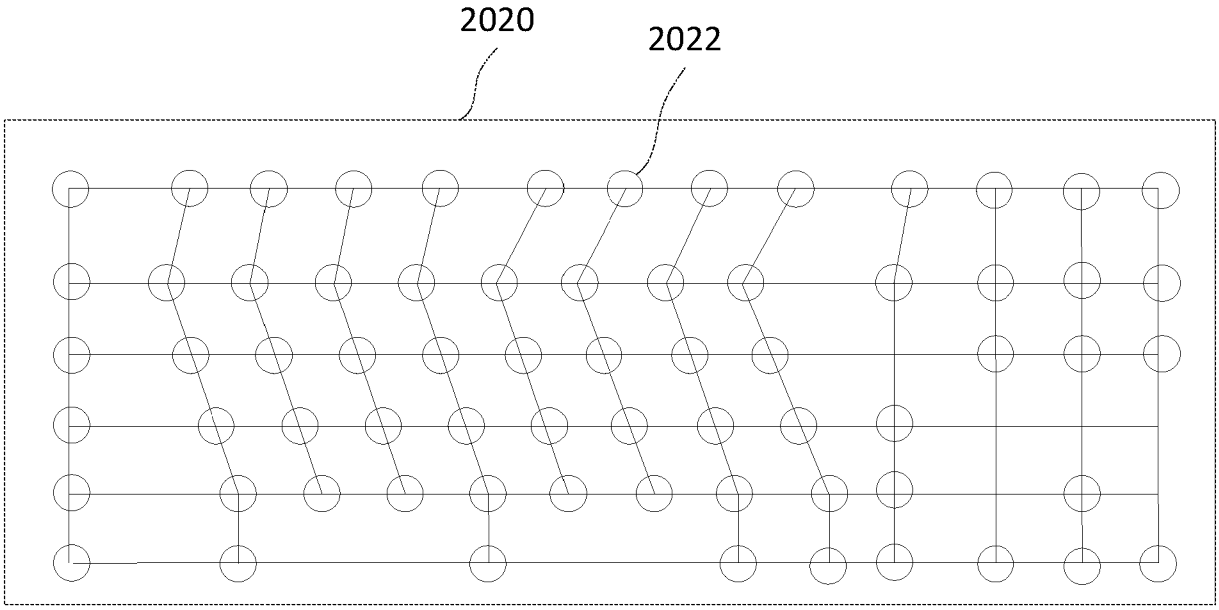


Figure 5a

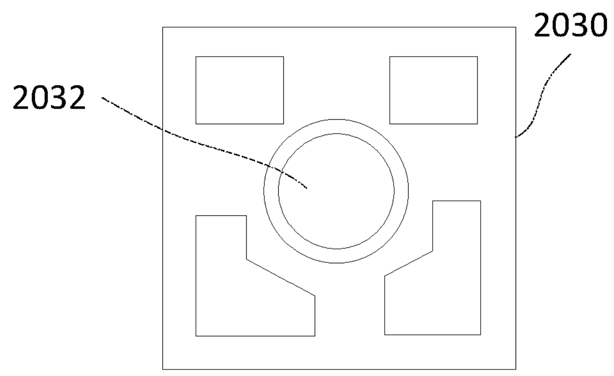


Figure 5b

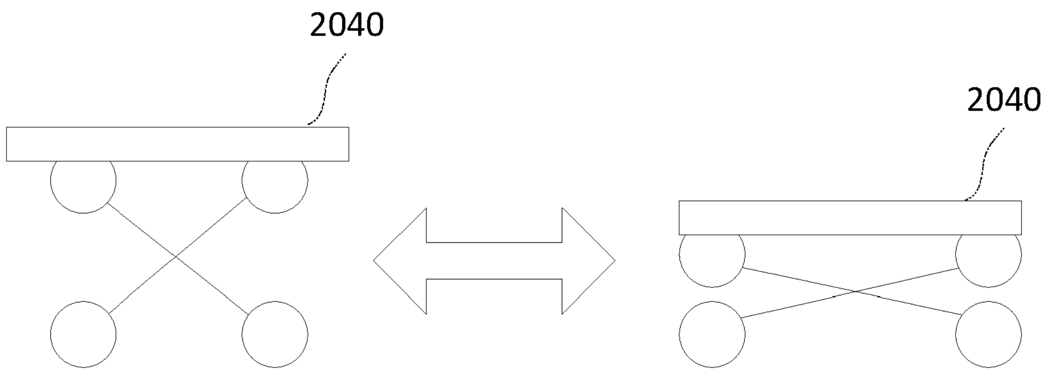


Figure 5c

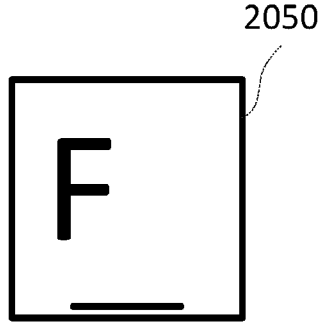


Figure 5d

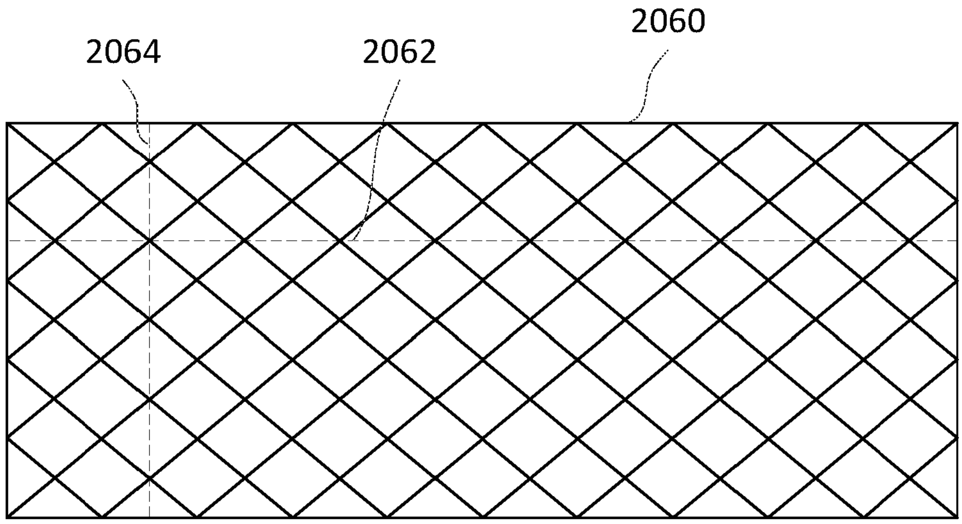


Figure 6a

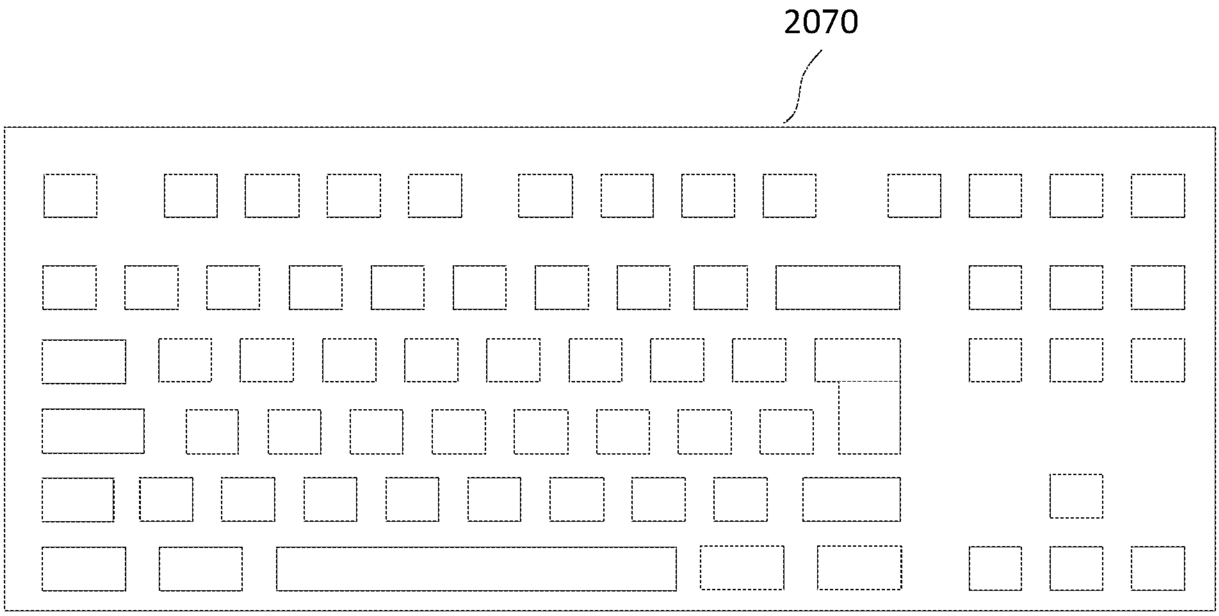


Figure 6b

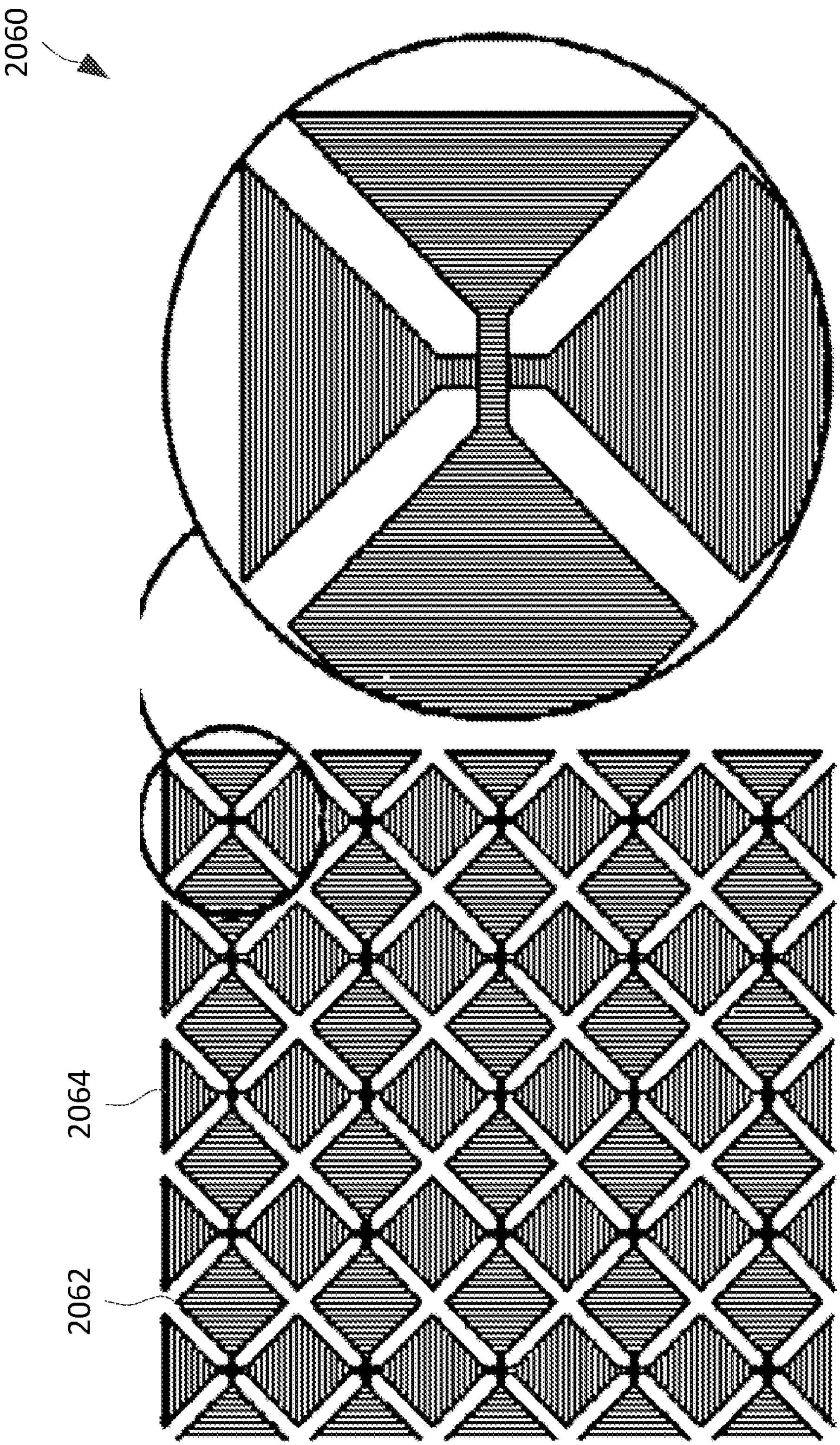


Figure 7

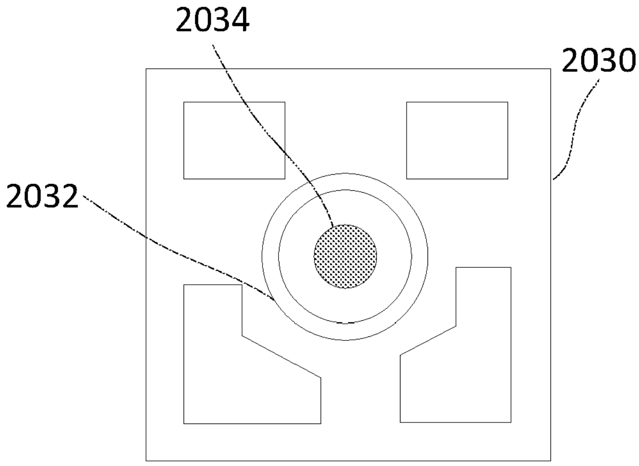


Figure 8

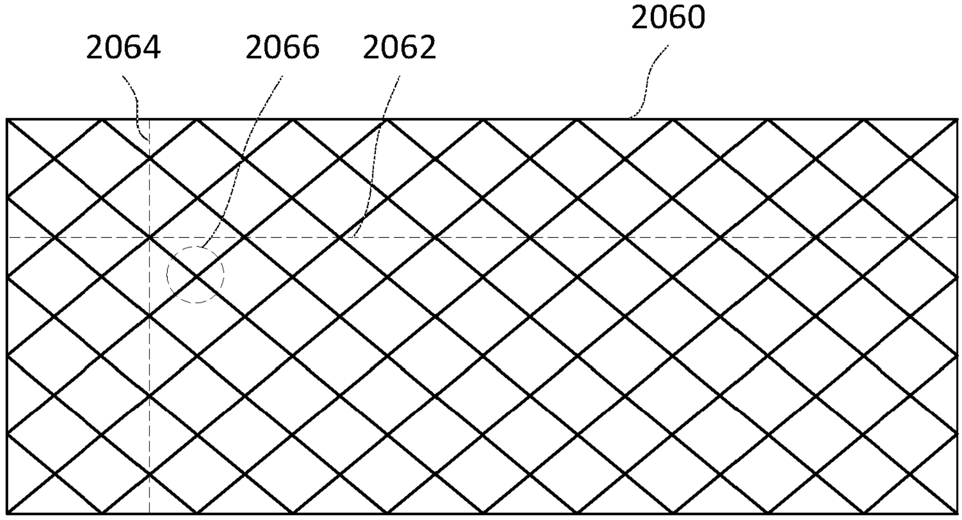


Figure 9

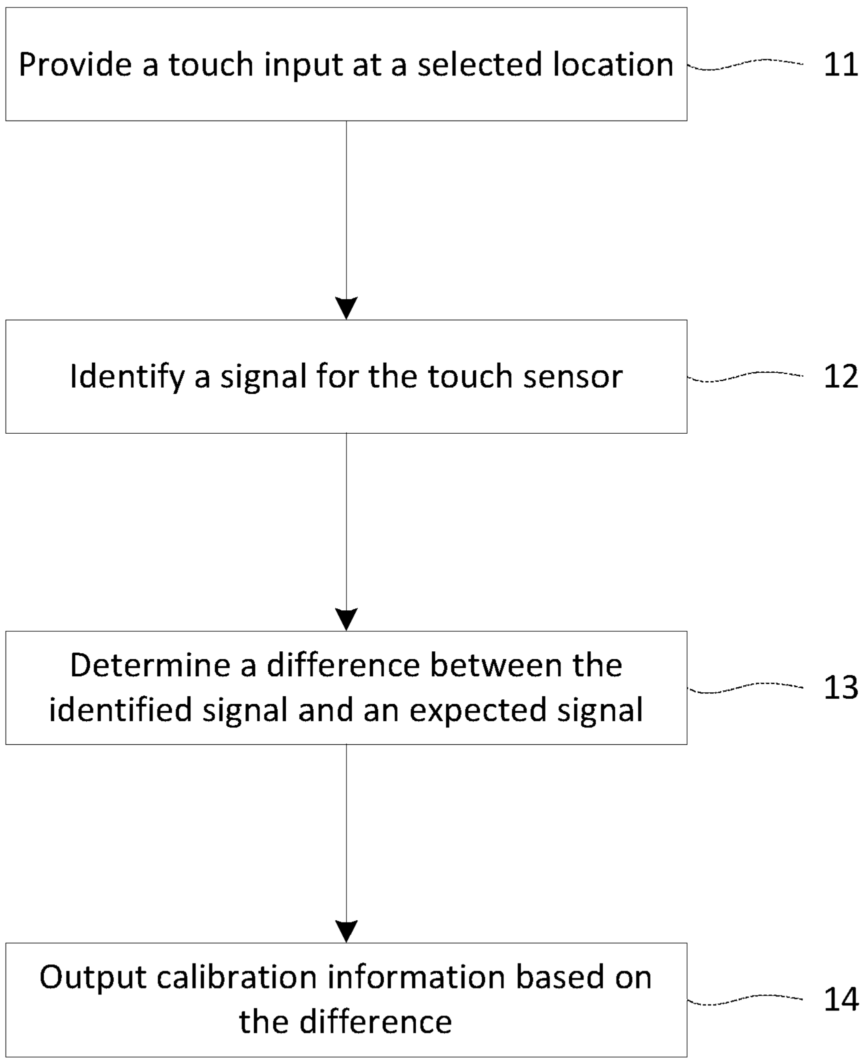

Provide a touch input at a selected location
11
Identify a signal for the touch sensor
12
Determine a difference between the identified signal and an expected signal
13
Output calibration information based on the difference
14

Figure 10

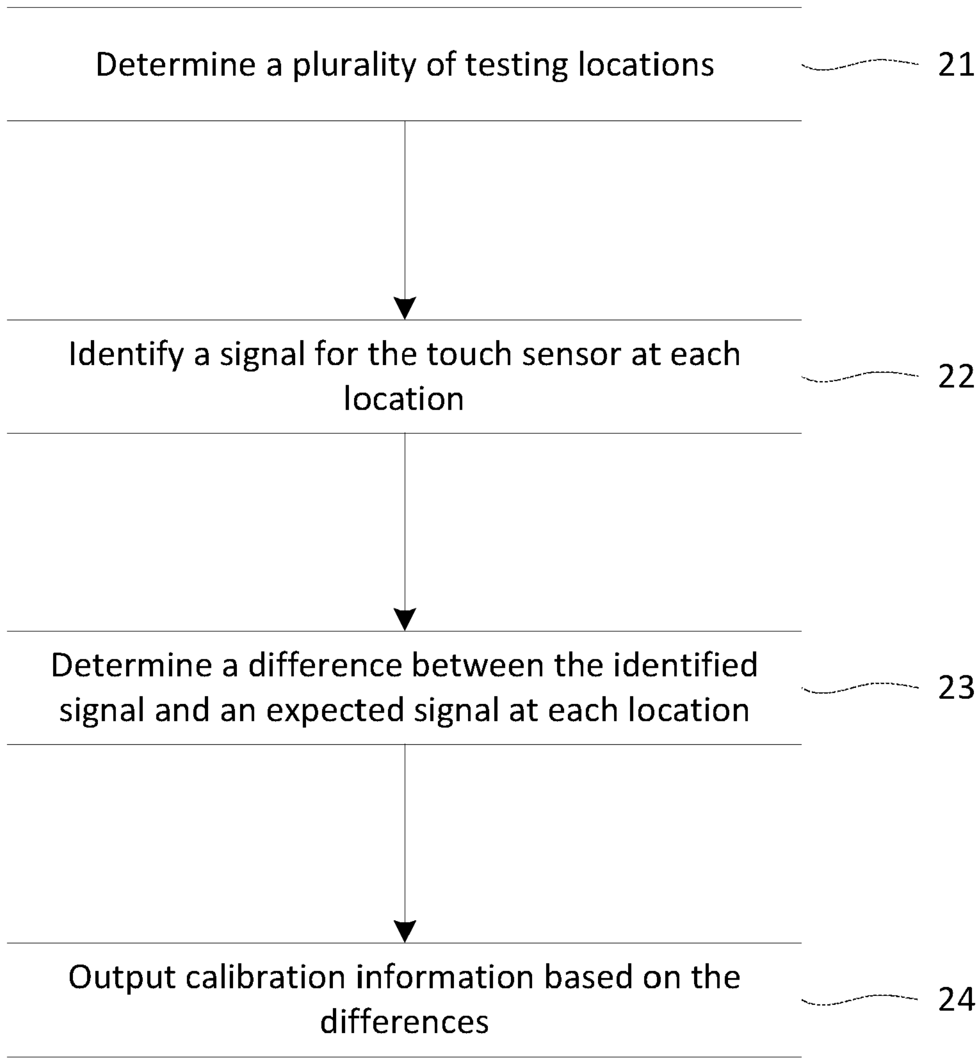

Determine a plurality of testing locations
21
Identify a signal for the touch sensor at each location
22
Determine a difference between the identified signal and an expected signal at each location
23
Output calibration information based on the differences
24

Figure 11

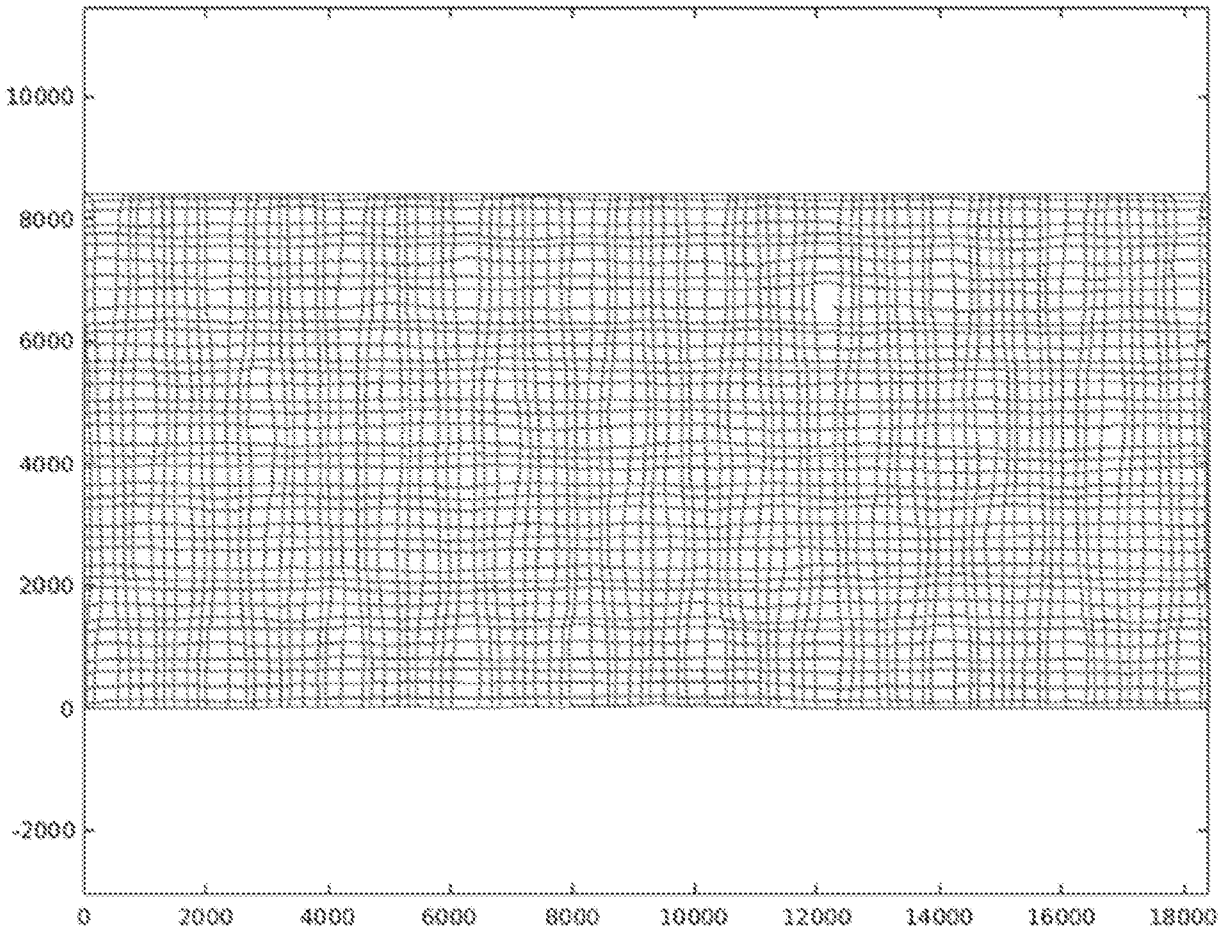

10000
8000
6000
4000
2000
0
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

Figure 12a

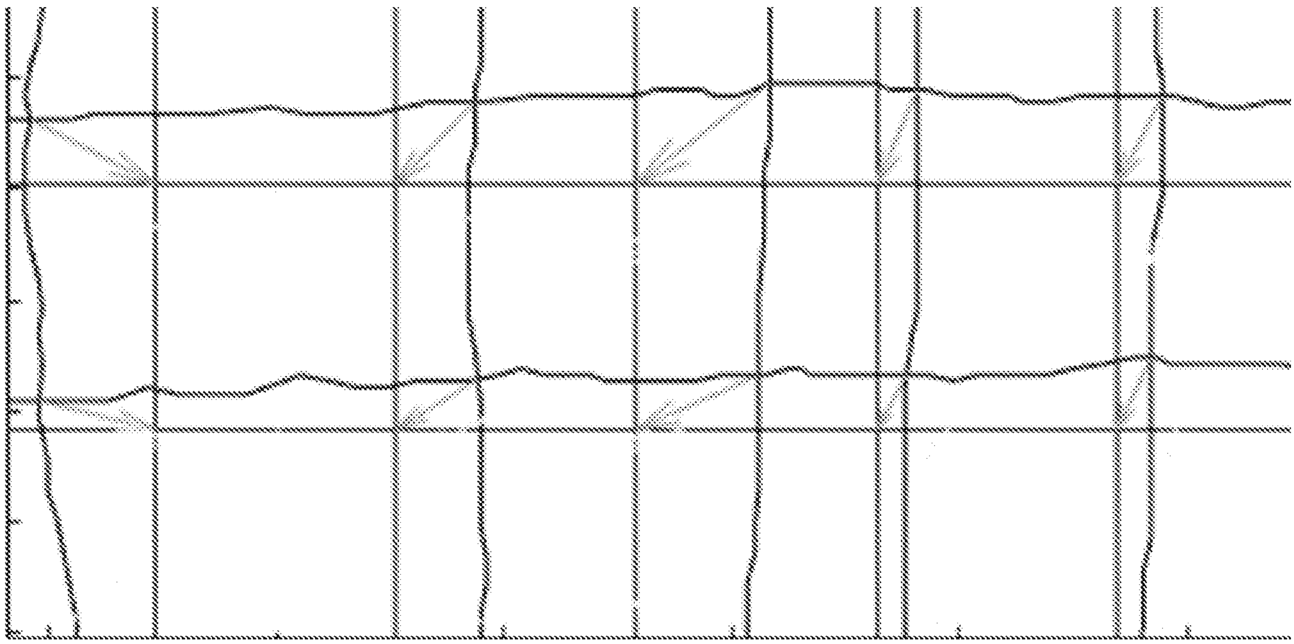


Figure 12b

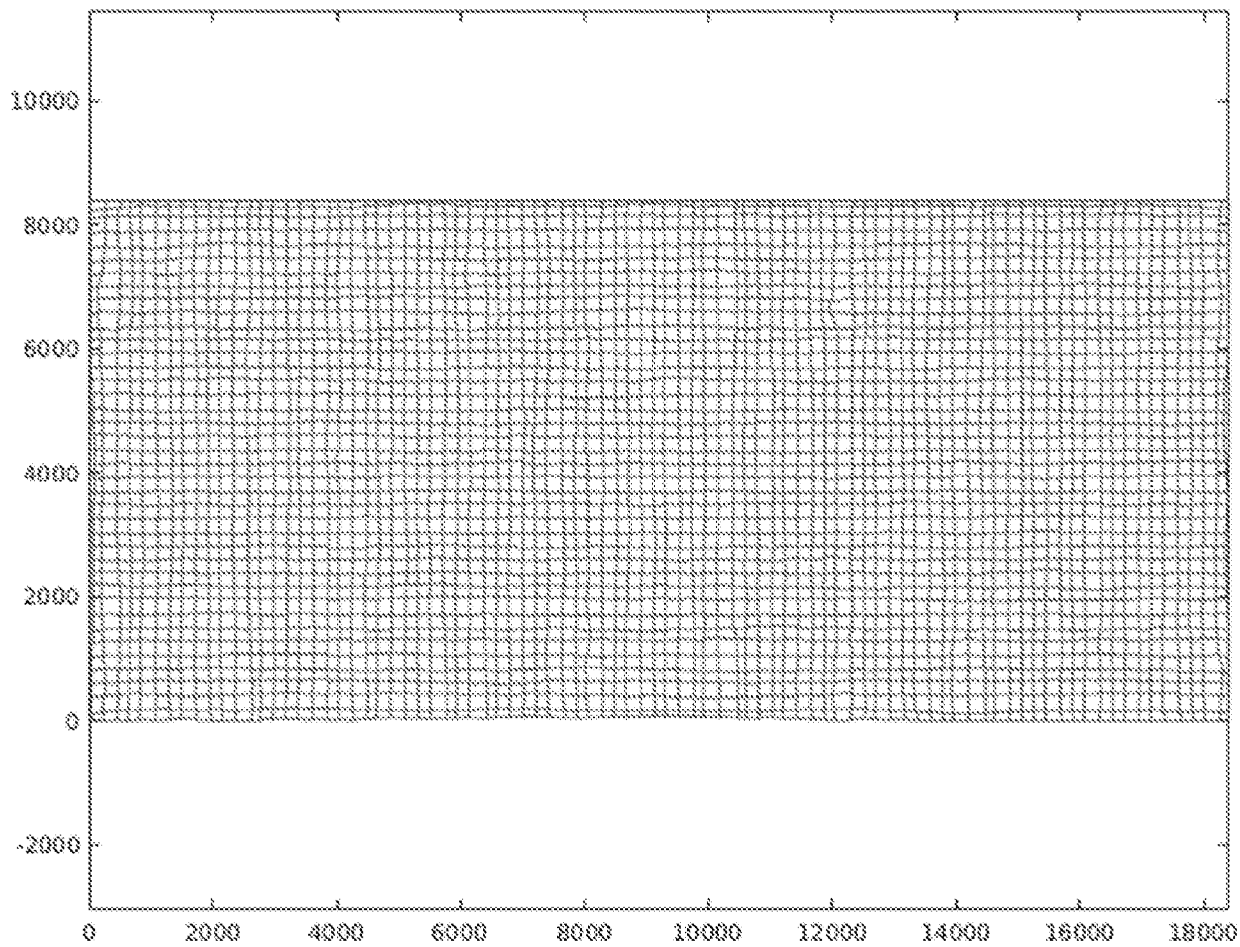
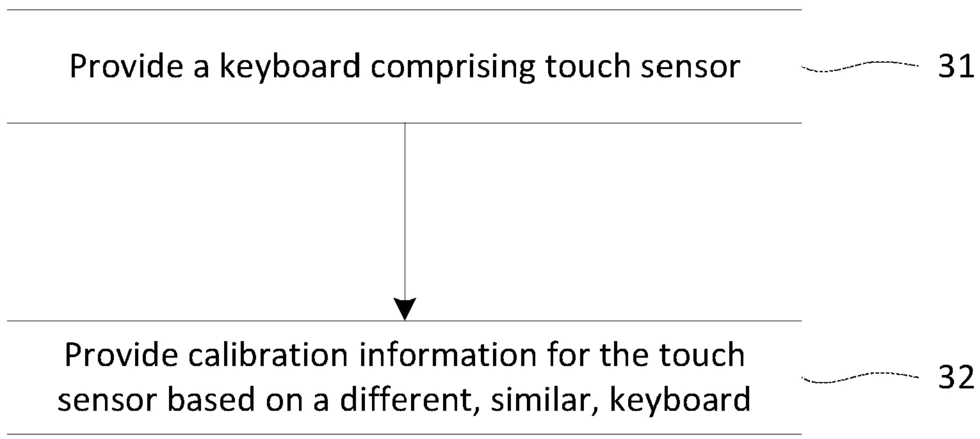

10000
8000
6000
4000
2000
0
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000

Figure 12c



Provide a keyboard comprising touch sensor
31
Provide calibration information for the touch sensor based on a different, similar, keyboard
32

Figure 13

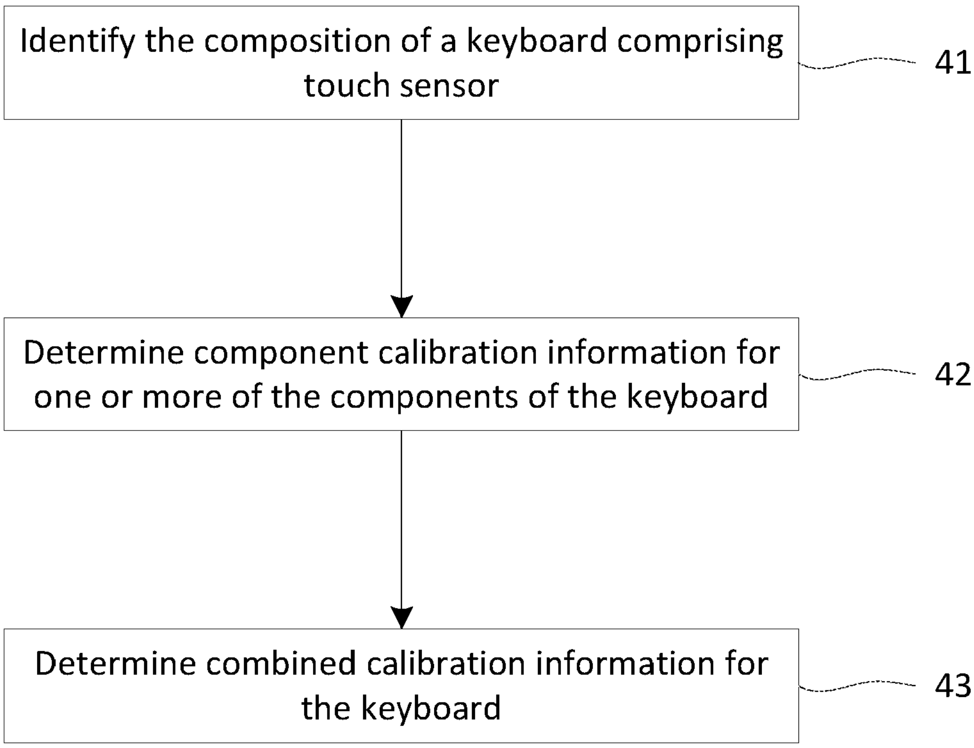

Identify the composition of a keyboard comprising touch sensor
41
Determine component calibration information for one or more of the components of the keyboard
42
Determine combined calibration information for the keyboard
43

Figure 14

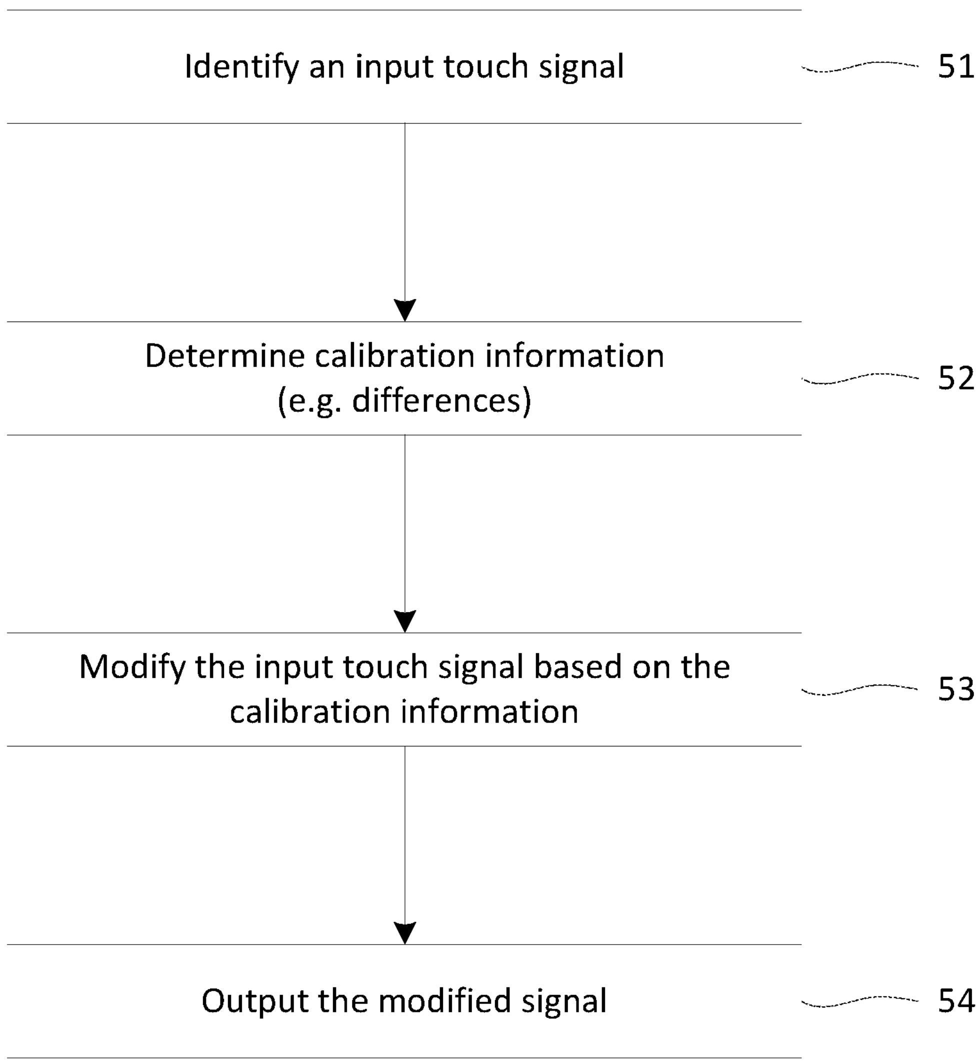

Identify an input touch signal
51
Determine calibration information
(e.g. differences)
52
Modify the input touch signal based on the
calibration information
53
Output the modified signal
54

Figure 15

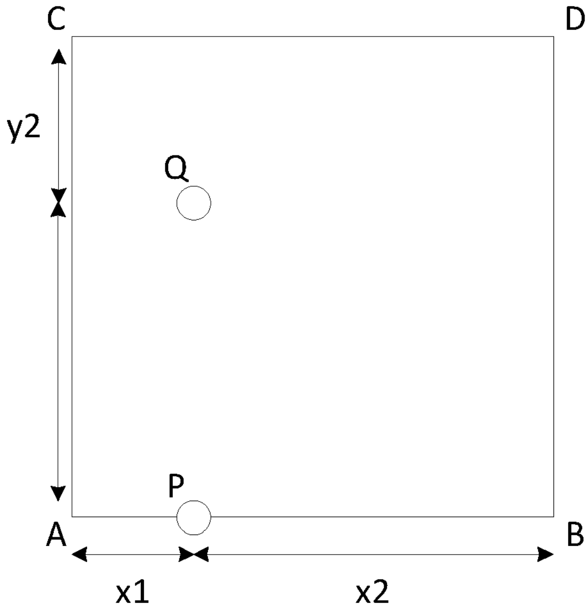


Figure 16

Keyboard

Field of the disclosure

The present disclosure relates to a keyboard. In particular the present disclosure relates to a method of associating calibration information with a keyboard. The disclosure further relates to: a computer device comprising calibration information for a keyboard; a keyboard; and a method of operating a keyboard.

Background to the Disclosure

A typical method of controlling the operation of computer devices is to use a keyboard and/or a touchpad. These components enable a user to interact with a computer, e.g. to send instructions to a processor. Ideally, these components are user-friendly; however, present keyboards and touchpads have a number of flaws.

A particular problem is that in order to use a conventional touchpad after typing a user must move their hand from the keyboard to the touchpad. In order to begin typing again at full speed, the user must move this hand back from the touchpad to the keyboard. While this movement can be quite quick, it is likely to be repeated thousands of times over the course of a year, which can lead to a significant cumulative time and focus requirement. Therefore, it would be beneficial to integrate a touch sensor with a keyboard to reduce the need for this movement. However, this integration can lead to a keyboard that lacks user friendliness and is bulky.

A solution to this problem is desired.

Summary of the Disclosure

According to an aspect of the present disclosure, there is described a method of associating calibration information with a keyboard comprising a touch sensor, the method comprising: determining calibration information for a further keyboard comprising a touch sensor; and associating the calibration information with the keyboard.

Preferably, the keyboard and the further keyboard are similar keyboards.

Preferably, the method comprises comprising determining calibration information for a plurality of further keyboards comprising similar touch sensors, combining this calibration information, and associating the combined calibration information with the keyboard.

Preferably, the plurality of further keyboards comprises a plurality of similar keyboards, more preferably a plurality of keyboards from the same product series. Preferably, the plurality of further keyboards comprises at least two further keyboards, at least five further keyboards, and/or at least ten further keyboards.

Preferably, combining the calibration information comprises averaging the calibration information and/or removing extreme (e.g. outlier) values from the calibration information.

Preferably, the keyboard and the further keyboard comprise the same components (and/or the same types of components) and/or are from the same product series.

Preferably, the keyboard and the further keyboard comprise the same protective plate (and/or the same type of protective plate). Preferably, for each keyboard the protective plate is associated with a/the corresponding touch sensor.

Preferably, associating the calibration information with the keyboard comprises outputting the calibration information to a storage of the keyboard and/or outputting the calibration information to a separate computer device associated with the keyboard.

Preferably, the calibration information relates to one or more of: a location; a magnitude; and a direction.

Preferably, the calibration information relates to a difference between an expected touch signal and a detected touch signal.

Preferably, the calibration information is arranged to be combined with a detected touch signal.

Preferably, determining calibration information comprises determining calibration information for a plurality of points on the further keyboard, preferably a grid of points on the further keyboard.

Preferably, determining calibration information comprises determining calibration information using a machine, preferably a computer numerical control (CNC) machine.

Preferably, the method comprises determining a variation between the keyboard and the further keyboard; determining modified calibration information based on the calibration information and the variation; and associating the modified calibration information with the keyboard.

Preferably, the variation is associated with a difference in componentry between the keyboard and the further keyboard.

Preferably, the method comprises determining component calibration information for one or more of the components of the further keyboard. Preferably, the method comprises determining component calibration information for one or more components of a plurality of further keyboards, and determining the calibration information based on the component calibration information.

Preferably, the method comprises assembling the further keyboard.

Preferably, the method comprises assembling the keyboard.

According to another aspect of the present disclosure, there is described a method of manufacturing a keyboard comprising: providing a keyboard comprising a touch sensor; and associating calibration information with the keyboard according to the method of any preceding claim.

According to another aspect of the present disclosure, there is described a computer device comprising calibration information for a keyboard that comprises a touch sensor, wherein the calibration information is dependent on a further keyboard comprising a touch sensor.

Preferably, the calibration information has been determined for the further keyboard and thereafter has been associated with the keyboard.

Preferably, the further keyboard is a further, similar, keyboard and/or a further keyboard of the same product series as the keyboard.

Preferably, the computer device is arranged to apply the calibration information to a touch signal detected by the touch sensor.

Preferably, the computer device is arranged to: detect an input touch signal; modify the input touch signal based on the calibration information; and output the modified touch signal.

Preferably, modifying the input touch signal comprises modifying one or more of: the direction of the touch signal; the magnitude of the touch signal; and the direction of the touch signal.

Preferably, modifying the input touch signal based on the comprises modifying the input touch signal based on a datapoint of the calibration information.

Preferably, modifying the input touch signal comprises modifying the input touch signal based on a plurality of datapoints of the calibration information.

Preferably, modifying the input touch signal comprises modifying the input touch signal based on an interpolated datapoint that is determined based on an interpolation of the plurality of datapoints.

Preferably, modifying the input touch signal comprises modifying the input touch signal based on an extrapolated datapoint that is determined based on an extrapolation of the plurality of datapoints.

Preferably, the method comprises modifying the input touch signal based on an interpolated datapoint that is determined based on a bilinear interpolation of the plurality of datapoints.

According to another aspect of the present disclosure, there is described a keyboard comprising and/or being the aforesaid computer device.

According to another aspect of the present disclosure, there is described a method of modifying an input touch signal detected by a keyboard comprising a touch sensor, the method comprising: detecting an input touch signal; modifying the input touch signal based on calibration information; and outputting the modified touch signal; wherein the calibration information is dependent on a further keyboard comprising a touch sensor.

Method of manufacture

According to another aspect of the present disclosure, there is described a keyboard comprising a touch sensor as aforesaid.

According to another aspect of the present disclosure, there is described a method of manufacturing a touch sensor as aforesaid.

According to another aspect of the present disclosure, there is described a method of manufacturing a keyboard as aforesaid.

According to another aspect of the present disclosure, there is described a method of manufacturing a touch sensor comprising forming a touch sensor. Preferably, the method comprises forming holes in the touch sensor.

According to another aspect of the present disclosure, there is described a method of manufacturing a keyboard comprising: providing a plurality of keys, wherein each of the keys comprises a keypress mechanism that is operated when the key is pressed; providing a base layer; and providing a keypress sensor layer for detecting the movement of the keys; wherein the keypress sensor layer is located between the base layer and the keypress mechanisms.

Preferably, forming the touch sensor comprises forming a grid of sensor elements. Preferably, forming the touch sensor comprises forming a grid of electrodes.

Preferably, forming the holes comprises forming the holes in dependence on the location of the sensor elements. Preferably, the holes are formed so as to not overlap the edges of the sensor elements sensor elements.

Preferably, forming the holes comprises forming holes of different sizes.

Preferably, the method further comprises affixing one or more transmittal mechanisms to the touch sensor.

According to another aspect of the present disclosure, there is described a method of manufacturing a keyboard comprising a base plate and a touch sensor.

Preferably, the method comprise adding an adhesive layer to the base plate and/or the touch sensor.

Preferably, the method comprises heating the base plate and/or the touch sensor.

Preferably, the method comprises removing air bubbles from the touch sensor.

Preferably, the method comprises pressing together two or more layers of the keyboard.

Preferably, the method comprises passing an attachment mechanism through a hole in the touch sensor. Preferably, the method comprises passing an attachment mechanism through the hole so as to mount a/the keypress mechanism of the keyboard on the base plate of the keyboard.

Preferably, the method comprises mounting one or more keypress mechanisms to a component of the keyboard, preferably mounting one or more keypress mechanisms to the base plate and/or a mechanism mounting plate.

Preferably, the method comprises attaching one or more keycaps to the keypress mechanisms.

Preferably, the method comprises aligning the keycaps with the transmittal mechanisms.

Preferably, the method comprises aligning a backlight with at least a subset of the holes of the touch sensor.

Preferably, the method comprises forming a key plate comprising a plurality of keys.

According to another aspect of the present disclosure, there is described a method of manufacturing a key plate comprising a plurality of keys.

Preferably, the method comprises forming a key plate comprising a plurality of integral keys.

Preferably, the method comprises cutting a key plate so as to form a plurality of keys.

Preferably, the method comprises engraving characters on one or more keys.

Preferably, the method comprises transferring calibration information to the keyboard, the calibration information being associated with the touch sensor.

According to another aspect of the present disclosure, there is described a method of manufacturing the aforesaid keyboard.

According to another aspect of the present disclosure, there is described a method of using the aforesaid keyboard.

Any feature in one aspect of the disclosure may be applied to other aspects of the invention, in any appropriate combination. In particular, method aspects may be applied to apparatus aspects, and vice versa.

Furthermore, features implemented in hardware may be implemented in software, and vice versa. Any reference to software and hardware features herein should be construed accordingly.

Any apparatus feature as described herein may also be provided as a method feature, and vice versa. As used herein, means plus function features may be expressed alternatively in terms of their corresponding structure, such as a suitably programmed processor and associated memory.

It should also be appreciated that particular combinations of the various features described and defined in any aspects of the disclosure can be implemented and/or supplied and/or used independently.

The disclosure also provides a computer program and a computer program product comprising software code adapted, when executed on a data processing apparatus, to perform any of the methods described herein, including any or all of their component steps.

The disclosure also provides a computer program and a computer program product comprising software code which, when executed on a data processing apparatus, comprises any of the apparatus features described herein.

The disclosure also provides a computer program and a computer program product having an operating system which supports a computer program for carrying out any of the methods described herein and/or for embodying any of the apparatus features described herein.

The disclosure also provides a computer readable medium having stored thereon the computer program as aforesaid.

The disclosure also provides a signal carrying the computer program as aforesaid, and a method of transmitting such a signal.

Where the disclosure references the keyboard being arranged to operate in a certain way, this may comprise the control unit being arranged to operate in a certain way (and *vice versa*).

As used herein, a touch of the user may refer to a touch of the user using an appendage of the user (e.g. a finger). Equally, a touch of the user may refer to a touch of the user using an implement, such as a stylus.

The disclosure extends to methods and/or apparatus substantially as herein described with reference to the accompanying drawings.

The disclosure will now be described, by way of example, with reference to the accompanying drawings.

Description of the Drawings

Figure 1 shows an exemplary user device with which the apparatus described herein may be used.

Figure 2 shows a keyboard.

Figure 3 shows layers of the keyboard.

Figure 4 shows a base plate that may be included in the keyboard.

Figure 5a – 5d show further layers of the keyboard that may be included in the keyboard.

Figure 6a shows a touch sensor that can be used with the keyboard.

Figure 6b shows a protective layer for protecting the touch sensor of Figure 6a.

Figure 7 shows a detailed example of a touch sensor.

Figure 8 shows a transmittal mechanism for use in detecting a keypress.

Figure 9 shows a capacitive touch sensor suitable for use with the transmittal mechanism of Figure 8.

Figure 10 shows a method of calibrating the touch sensor.

Figure 11 shows another method of calibrating the touch sensor.

Figures 12a – 12c show examples of a practical implementation of the method of Figure 11.

Figure 13 shows a method of providing calibration information for a keyboard based on calibration information for a further keyboard.

Figure 14 shows a method for determining calibration information for a keyboard based on the componentry of the keyboard.

Figure 15 shows a method of operating a keyboard based on calibration information.

Figure 16 shows a method of interpolating calibration information.

Description of the preferred embodiments

Referring to Figure 1, there is shown an exemplary computer device 1000.

The computer device 1000 comprises a processor in the form of a CPU 1002, a communication interface 1004, a memory 1006, storage 1008, and a user interface 1010, where the components are connected by a bus 1012. The user interface 1010 typically comprises a display 1016 and one or more input/output devices; in this embodiment the user interface 1010 comprises a keyboard 2000 and a pointer input 3000.

The CPU 1002 executes instructions, including instructions stored in the memory 1006 and the storage 1008.

The communication interface 1004 is typically a Bluetooth® interface that enables the computer device 1000 to be coupled with other devices comprising a Bluetooth® interface. It will be appreciated that the communication interface 1004 may comprise any other communications technology, such as an area network interface and/or an Ethernet interface. The communication interface 1004 may comprise a wireless interface or a wired interface, such as a universal serial bus (USB) interface.

The memory 1006 stores instructions and other information for use by the CPU 1002. Typically, the memory 1006 usually comprises both Random Access Memory (RAM) and Read Only Memory (ROM).

The storage 1008 provides mass storage for the computer device 1000. Depending on the computer device 1000, the storage 1008 is typically an integral storage device in the form of a hard disk device, a flash memory or some other similar solid state memory device, or an array of such devices.

The user interface 1012, and in particular the keyboard 2000 and the pointer input 3000 are used to control the computer device 1000, where these components enable the user to pass instructions to the CPU 1002. Typically, the pointer input comprises a touch sensor and/or a computer mouse.

The keyboard 2000 and the pointer input 3000 may be integrated with the computer device 1000 or may be removable components. For example, the keyboard 2000 and the pointer input 3000 may be connected to the computer device 1000 by an, optionally removable, wire, such as a USB connection

In some embodiments, the keyboard 2000 and/or the pointer input 3000 is wirelessly connected to the computer device 1000, for example using a Bluetooth® connection.

The present disclosure relates, in part, to a combined keyboard and pointer input, where a pointer input means (e.g. a touchpad) is integrated with the keyboard 2000. As an example, a capacitive sensor may be integrated with the keyboard 2000, where the capacitive sensor detects when the user touches the keys of the keyboard 2000.

It will be appreciated that as well as capacitive sensors other technologies can be used to detect a user touching the keys of the keyboard 2000. As an example, optical sensors may be used, where these optical sensors may detect movement of an object a certain distance from the keyboard 2000 and/or touchpad 3000. Similarly, pressure sensors may be used, where the pressure sensors may be included in the keys of the keyboard 2000 or placed above/below the keys. In various embodiments, the touch sensor comprises one or more of: a camera; acoustic sensors; temperature sensors; magnetic sensors (e.g. Hall sensors); piezoelectric sensors; and triboelectric sensors.

Referring to Figure 2, the keyboard 2000 is shown in more detail.

The keyboard 2000 comprises a number of keys 2002 and a connection interface 2004. The keys 2002 are arranged to detect a user input, e.g. from a user pressing the keys 2002. The connection interface 2004 is arranged to connect the keyboard to the computer device 1000. The connection interface 2004 may comprise a USB connection, a Bluetooth® interface, or a radio interface (e.g. at 2.4GHz or 5GHz).

In some embodiments, the keyboard 2000 comprises a computer device and/or comprises components similar to the computer device 1000. In particular, the keyboard 2000 may comprise a processor, a communication interface, a memory, storage, and/or a user interface. This enables the keyboard to execute instructions itself (without requiring the assistance of a separate computer device).

It will be appreciated that any layout of keyboard may be used; for example, a full-size keyboard, a ‘tenkeyless’ keyboard, or a ‘60%’ keyboard. Furthermore, the layout and properties of the keys 2002 on the keyboard 2000 may vary.

Referring to Figure 3, the keyboard 2000 is typically composed of a plurality of layers.

Certain layers that may form a part of the keyboard 2000 are described with reference to Figures 4 and 5a-5d.

In particular, referring to Figure 4, there is disclosed a base plate 2010, which comprises a plurality of hook mounts 2012. The hook mounts 2012 of the base plate 2010 are arranged to pass through each other layer of the keyboard 2000 in order to attach to a keypress mechanism, such as a scissor mechanism. Various other keypress mechanisms are known in the art. The keyboard 2000 may also comprise a touch sensor (which touch sensor is typically a part of a touch sensor layer); this touch sensor is typically arranged to allow passage of the hook mounts 2012, e.g. by the touch sensor comprising holes through which the hook mounts 2012 can pass.

The hook mounts 2012 typically comprise extensions, which are designed to pass through the other layers in order to fit inside recesses of another layer. Alternatively, the hook mounts 2012 may comprise recesses, into which extensions of another layer are arranged to fit.

In some embodiments, the base plate 2010 comprises holes 2014 to allow the passage of light. This allows a backlight to be located behind the base plate 2010, where this backlight is able to provide a light that passes through the holes 2014 of the base plate 2010.

The base plate 2010 is a rigid structure that is typically formed of metal; this provides rigidity to the entire keyboard 2000.

Referring to Figures 5a – 5d, there is described other layers that may form a part of the keyboard 2000.

Referring to Figure 5a, there is shown a keypress sensor layer 2020. The keypress sensor layer 2020 is arranged to record keystrokes, e.g. when a user presses the key 2002. Typically, this is achieved by arranging a plurality of sensors 2022 on the keypress sensor layer 2020, where each sensor is arranged to detect the pressing of a single key.

In some embodiments, the keyboard 2000 is a membrane keyboard. In such embodiments, the keypress sensor layer 2020 comprises a series of conductive portions with there being two conductive portions between each key. A further conductive portion is present at the base of the key, so that when the key is pressed the two conductive portions of the keyboard sensor layer 2020 are connected.

In order to determine a keypress, the keyboard 2000 typically comprises a control unit (not shown) that continuously scans the keypress sensor layer 2020 in order to determine the presence of a current. In various embodiments, the scan rate and the scan pattern of the controller differ; e.g. a higher scan rate of the controller may be desirable to reduce the latency of a keypress, but this may reduce accuracy by being more likely to pick up a false keypress.

In some embodiments, the keyboard 2000 is a mechanical keyboard and each key is connected to a separate switch. Pressing a key operates the corresponding switch, thereby a keypress can be detected.

Typically, the keyboard 2000 is a membrane keyboard and the keypress sensor layer 2030 is formed by bonding together one or more polyethylene terephthalate (PET) membranes. The plurality of keypress sensors (e.g. conductive portions) are located within the PET membranes.

Referring to Figures 5b – 5d, each key 2002 typically comprises a transmittal mechanism 2030, a keypress mechanism 2040, and a keycap 2050. The keycap 2050 enables the user to interact with the remainder of the key 2002; the transmittal mechanism 2030 connects the keycap 2050 to the keypress sensor layer 2020 so that a keypress can be detected; the keypress mechanism 2040 is an optional feature of the key 2002 that is arranged to provide a stable keypress (e.g. ensure that the force resisting a keypress is relatively constant throughout the distance of travel of the key 2002).

The keypress mechanism 2040 also maintains the horizontal position of the keycap 2050 throughout the travel of the key to ensure that the keycap 2050 being pressed (at any location on the keycap 2050) results in a depression of the transmittal mechanism 2030.

Typically, the transmittal mechanisms 2030 are mounted on the touch sensor layer 2020. In some embodiments, the transmittal mechanisms 2030 are arranged so that the depression of a keycap results in a part of a corresponding transmittal mechanism impacting the touch sensor layer 2020. In some embodiments, the transmittal mechanisms 2030 are arranged so that the depression of the keycap 2050 results in a part of a corresponding transmittal mechanism passing through a hole of the touch sensor layer 2020.

Referring to Figure 5b, there is shown an embodiment of the transmittal mechanisms 2030. In this embodiment, the transmittal mechanisms 2030 comprise a plurality of silicone domes 2032, where there is a silicone dome for each key of the keyboard 2000. The silicone domes 2032 are arranged so that when the user presses a key of the keyboard 2000 a corresponding silicone dome is compressed, and this dome actuates a sensor of the keypress sensor layer 2020. The sensor 2022 is thus able to detect that a key has been pressed. The silicone domes 2032 also cushion the depression of the keys 2002 and provide a return force that raises a key once the user has released pressure on that key.

It will be appreciated that there are a number of other types of transmittal mechanisms may be used to detect the depression of a key, such as metal domes or mechanical linkages (e.g. push switches and/or springs).

Referring to Figure 5c, there is shown an embodiment of the keypress mechanism 2040, in this embodiment of the keypress mechanism 2040 is a scissor mechanism. The scissor mechanism comprises two interlocking parts that are typically composed of plastic. The interlocking parts are arranged to bias the key 2002 in a raised position and/or to resist the depression of the key 2002. When the user applies pressure to the key 2002, the key 2002 is depressed, which forces the base of each interlocking part away from the base of the other interlocking part so that the key 2002 can be depressed. When the user releases the pressure, the biasing force acts to raise the key 2002. This movement is shown in Figure 5c.

Referring to Figure 5d, there is shown a keycap 2050. The keycap 2050 is placed on top of the transmittal mechanism and the keypress mechanism 2040 so that pressure applied to the keycap 2050 is transmitted to the transmittal mechanism 2030 and the keypress mechanism 2040. The keycap 2050 protects the remainder of the layers to minimise wear and increase the lifespan and usability of the keyboard 2000. Typically, each keycap has a different symbol printed onto it, e.g. a letter or a number, to enable the user to determine the consequence of depressing the keycap

2050 (e.g. depressing a keycap 2050 that has “F” printed on it will result in the letter f being typed and shown on the display 1012).

The keypress mechanism 2040 is mounted on a layer of the keyboard 2000, which may be a separate layer to those described above. In typical keyboards the keypress mechanism 2040 is mounted to a layer that is located towards the top of the keyboard 2000, e.g. the keypress mechanism 2040 is mounted to a layer immediately below the level of the keypress mechanisms 2040.

The present disclosure considers, in part, a keyboard in which the hook mounts 2012 on which the keypress mechanisms 2040 are mounted are a part of the base plate 2010. Each other layer of the keyboard 2000 is arranged so that the hook mounts 2012 are able to pass through these layers in order to attach to the keypress mechanisms 2040; in particular, a touch sensor layer is arranged to enable the passage of the hook mounts. The base plate 2010 therefore provides both rigidity for the keyboard 2000 and a mounting means for the keypress mechanisms 2040. This enables each keypress mechanism 2040 to be secured without the need for a separate securing layer, which allows the provision of a thin keyboard.

Touch sensor

Referring to Figure 6a, there is shown a touch sensor in the form of a touch sensor layer 2060 that is suitable for inclusion within the keyboard 2000. The touch sensor layer 2060 is arranged to detect the presence of an object on or above the keyboard 2000.Typicallty, this detection is achieved by the touch sensor layer comprising a plurality of sensing elements. In this embodiment, the touch sensor layer 2060 comprises a capacitive sensor that is capable of detecting a user’s finger touching the keyboard 2000 due to a change in the local electric field caused by the finger. Typically, the touch sensor layer 2060 is arranged to determine one or more of: a number of objects above the keyboard 2000, a position of those objects, a motion of those objects, a trajectory of those objects, and/or a speed of those objects.

In some embodiments, the touch sensor layer 2060 comprises other sensors, such as optical sensors, pressure sensors, accelerometers, or audio sensors. Generally, the touch sensor layer 2060 may comprise any sensor and/or component that is capable of detecting the position and/or movement of a user and/or object.

Where a capacitive sensor is used the capacitive sensor typically comprises a grid formed of rows 2062 and columns 2064 of electrodes. A controller is arranged to drive a current through a single row of the touch sensor layer 2060 and then to scan (in order) each column of the touch sensor layer 2060 for an induced current; this process is repeated for each row. The current induced in a given column will depend on whether a user (e.g. a user’s finger) is near the row being driven. With a mutual capacitance sensor, the capacitance value at each intersection can be evaluated separately so that the sensing of multiple touch points is possible. Other capacitive sensors, such as self-capacitance sensors, may also be used – for some of these sensors, detection of multiple touch points may not be possible. A more detailed view of a capacitive touch sensor is described below with reference to Figures 8a – 8c. More generally, any grid of sensor elements may be used to detect a touch input, e.g. a grid of pressure sensors or optical elements may be used.

In this embodiment, there is provided a capacitive sensor with rows and columns arranged in a diamond formation as shown in Figure 6a, where the separations between the rows 2062 and the columns 2064 of the capacitive sensor are at an angle compared to the edges of the keyboard 2000. Other arrangements may be used, e.g. a comb arrangement where the separations between the rows and columns of electrodes are parallel to the edges of the keyboard 2000.

In order to sense the presence of an object, the touch sensor layer 2060 may be located near the top of the keyboard, e.g. immediately beneath the keypress mechanism 2040 or the transmittal mechanism 2030. Proximity to the keycaps 2050 enables simple sensing of a user's touch on the keycaps 2050. In order to amplify the capacitive effect of the user's touch on the keycaps 2050, there may be provided a conductive material on the keycaps 2050 or an electrical connection between the keycaps 2050 and the touch sensor layer 2060. The use of a conductive material may be particularly beneficial when the touch sensor layer 2060 is distant from the keys 2002.

Typically, the touch sensor layer 2060 is located above the keypress sensor layer 2020 and below the level of the keypress mechanisms 2040; this arrangement places the touch sensor layer 2060 close enough to the top of the keyboard 2000 to detect the touch of a user on the keycaps 2050 of the keyboard 2000 while enabling the touch sensor layer 2060 to be provided as a single plate (since the touch sensor layer 2060 does not move due to a movement of the keys 2002. More generally, the touch sensor layer 2060 is typically located below the layer of the keypress mechanisms 2040 so as to allow provision of the touch sensor layer 2060 as a single plate.

In some embodiments, the touch sensor layer 2060 comprises holes that enable the passage of the hook mounts 2012 of the base plate 2010; this enables the hook mounts 2012 (or a component that can be secured to the hook mounts 2012) to pass through the touch sensor layer 2060 so that the keypress mechanisms 2040 can be secured to the hook mounts 2012.

Where the touch sensor layer 2060 is provided above the keypress sensor layer 2020, the keypress sensor layer 2020 may be arranged to detect the depression of the transmittal mechanisms 2030 through the touch sensor layer 2060. As an example, the depression of the transmittal mechanisms 2030 may apply a pressure to the touch sensor layer 2060 that results in the depression of the portion of the touch sensor layer 2060 directly beneath the pressed key; this depression of the touch sensor layer 2060 is detected by the sensor 2022 of the keypress sensor layer 2020.

In some embodiments, there are provided holes in the touch sensor layer 2060 to enable the transmittal mechanisms 2030 (or a part of the transmittal mechanisms 2030) to pass through the touch sensor layer 2060 so as to actuate the sensors 2022 of the keypress sensor layer 2020.

The holes in the touch sensor layer 2060 are typically arranged so that they do not overlap with any intersections of the rows 2062 and columns 2064 of electrodes of the touch sensor layer 2060. For example, the touch sensor layer 2060 may comprise one or more holes located entirely between the diagonal separation lines of electrodes of the touch sensor layer 2060. This is described in more detail in reference to Figures 8a – 8c.

Referring to Figure 6b, where the touch sensor layer 2060 is provided, a protective layer 2070 may be provided to protect the touch sensor layer 2060 from dust and moisture. The protective layer 2070 is typically made of a plastic material and/or a thin film.

The protective layer 2070 is typically located above the touch sensor layer 2060. Like the touch sensor layer 2060, the protective layer 2070 may comprise holes so as to allow the passage of transmittal mechanisms 2030. The transmittal mechanisms 2030 may then be mounted on the protective layer 2070. In this situation, the touch sensor layer 2060 and the protective layer 2070 may be considered to be a single combined touch sensor/touch sensor layer (so that the transmittal mechanisms 2030 being mounted on the protective layer 2070 effectively involves the transmittal mechanisms 2030 being mounted on a touch sensor).

More generally, each layer of the keyboard 2000, and/or each layer between the base layer 2010 and the keypress mechanisms 2040 may comprise holes. Typically, each layer comprises concentric holes so that the hook mounts 2012 (or light) can pass through each layer.

In some embodiments, a backlight is provided so that a user can easily use the keyboard 2000 without an external light source. In these embodiments, there is typically a light guide layer (not shown) included in the keyboard, which light guide layer directs the lights to pass through the keycaps 2050 of the keyboard 2000. In these embodiments, the protective layer 2070 may be transparent or comprise transparent portions.

Typically, the light guide layer and/or the optical elements that provide light for the backlight are placed either at the base of the keyboard (beneath the base plate 2010); above the touch sensor layer 2060; in or on the touch sensor layer 2060 (e.g. so that the backlight is integrated with the touch sensor/touch sensor layer 2060); or above the protective layer 2070.

Each layer is typically secured to the other layers with an adhesive layer, e.g. a layer of glue or an adhesive tape (e.g. a double sided adhesive tape). Securing the layers together ensures that the rigid base plate 2010 is able to provide rigidity to the remainder of the layers. The adhesive layer may comprise a melted layer (e.g. of melted plastic) that acts to secure adjacent layers.

The hook mounts 2012 are arranged to pass through the touch sensor layer 2060 and the protective layer 2070 in order to secure the keypress mechanisms 2040; this also provides rigidity to the intervening layers.

While it will be appreciated that the layers of the keyboard 2000 may be arranged in any order – and any combination of layers may be provided and/or removed – a preferred arrangement of the layers is as follows:

1. (optionally) The light guide layer (not shown).
2. The base plate 2010.
3. (optionally) A layer of adhesive.
4. The keypress sensor layer 2020.
5. (optionally) A layer of adhesive.
6. The touch sensor layer 2060.
7. (optionally) A layer of adhesive.
8. (optionally) The protective layer 2070.
9. The transmittal mechanisms 2030.
10. The keypress mechanisms 2040.
11. The keycaps 2050.

As has been described above, typically the base layer 2010 comprises hook mounts 2012 that pass through each of the layers between the base plate 2010 and the keypress mechanisms 2040 (including the touch sensor layer 2060).

As has been described above, the transmittal mechanisms 2030 may be arranged to pass through the other layers so as to be able to actuate the sensors 2022 of the keypress sensor layer 2020.

Furthermore, the transmittal mechanisms 2030 may pass through, or be located internally to, the keypress mechanisms 2040, so that the keypress mechanisms 2040 are effectively adjacent to the protective layer 2070.

Typically, the transmittal mechanisms 2030 (e.g. silicone domes) are mounted on the touch sensor layer 2060, where the depression of the transmittal mechanism 2030 may result in a part of the transmittal mechanism 2030 passing through a hole of the touch sensor layer 2060.

Typically, a ground layer is located between the keypress sensor layer 2020 and the touch sensor layer 2060; for example, directly above the keypress sensor layer 2020. This ground layer is arranged to prevent interference between the keypress sensor layer 2020 and the touch sensor layer 2060.

There is disclosed herein a method of detecting keypresses using the touch sensor layer 2060. In these embodiments, the keyboard 2000 may be provided without the keypress sensor layer 2020.

In these embodiments, and other embodiments, the keyboard 2000 may be provided without the base plate 2010. Where the keyboard 2000 is provided without the base plate 2010 in particular (but also where the keyboard 2000 has the base plate 2010), the touch sensor layer 2060 may be provided as a rigid layer that provides rigidity to the keyboard 2000; for example, the touch sensor layer 2060 may comprise an FR4 material.

In some embodiments, the keyboard 2000 comprises (optionally, only):

1. A touch sensor layer 2060, which may also be used to detect keypresses, as is described further below.
2. Keycaps 2050.

In such embodiments, the keycaps 2050 may perform certain functions of the transmittal mechanisms 2030 and the protective layer 2070 (e.g. the operation of the touch sensors). Typically, such embodiments further comprise keypress mechanisms 2040 between the touch sensor layer 2060 and the keycaps 2050. As is described further below, these keypress mechanisms 2040 may also provide some of the functionality that is conventionally provided by the transmittal mechanisms 2030.

In these embodiments in particular, the keycaps 2050 may each be associated with (e.g. comprise) a conductive and/or metal element. In particular, there may be a metal coating arranged on or in the keycaps (e.g. embedded in layers of silicon). In a preferred embodiment, there are metal elements (e.g. embedded in layers of silicon) located on each corner of some or all of the keycaps 2050. This aids in the detection of a keypress by the keypress sensor layer 2020 (where a keypress sensor layer is used) and/or the touch sensor layer 2060 (as is described further below).

Where a keypress sensor layer 2020 is provided, this may be provided in combination with the touch sensor layer 2060 (e.g. in a combined printed circuit board (PCB) layer).

As has been explained with reference to Figure 5a, keypresses can be detected using a keypress sensor layer that contains a number of sensors to detect the pressing of a key.

An aspect of the present disclosure relates to instead (or additionally) determining keypresses using the touch sensor layer 2060. In particular, where the touch sensor layer 2060 comprises a capacitive sensor, the transmittal mechanism 2030 may be arranged so that pressing the key 2002 results in a change in the local electric field near the touch sensor layer 2060.

As shown in Figure 9, one way of achieving this is by attaching a coating 2034, e.g. a metal coating, to the transmittal mechanisms 2030 and/or the base of the keys 2002 so that when a key is pressed a corresponding coating approaches and/or contacts an electrode of the touch sensor layer 2060. This presence of the coating 2034 results in a determinable alteration of the local electric field beneath the pressed key. This alteration can be detected using the touch sensor layer 2060.

In various embodiments, the coating 2034 comprises one or more of: a metal coating, an electrically conductive coating, a metal oxide semiconductor coating, and an electrically insulating coating. Typically, the coating 2034 is arranged to cause a greater alteration to the local electric filed than the presence of a user's finger alone (e.g. an alteration at least twice the alteration due to a user's finger). It will be appreciated that the disclosures herein may also be used without a coating (e.g. where keypresses are detected based on a magnitude and/or a direction of a movement of a user's finger).

The coating 2034 may be located on any component that moves when the keycap 2050 is depressed. Typically, the coating is located on the keycap 2050 (e.g. on the underside of the keycap) and/or on the transmittal mechanism 2030 (e.g. on the exterior of the silicone dome 2032 or on the interior of the silicone dome 2032). In other words, the coating 2034 is arranged so that the coating 2034 is moved when the keycap 2050 is pressed.

In order to increase the sensitivity of the touch sensor layer 2060 and improve the detection of keypresses, in some embodiments the touch sensor layer 2060 is arranged so that the coating 2034 on the transmittal mechanism 2030 is located above an intersection of the rows and columns of the touch sensor layer 2060. This is illustrated in Figure 9, which shows an exemplary contact point 2066 (or a nearest approach point) on the touch sensor layer 2060. This contact point 2066 is arranged to be located beneath the coating 2034 of a key of the keyboard 2000 so that when the key is depressed, the coating 2034 approaches the contact point 2066.

In some embodiments, the transmittal mechanism 2030 and/or the coating 2034 is located above the centre of a sensor of the touch sensor layer 2060 (e.g. to be at the centre of an electrode). In some embodiments, the transmittal mechanism and/or the coating of one or more keys is arranged to be at the intersection of a row of electrodes and a column of electrodes (e.g. the point at which the necks of two electrodes overlap).

By using the touch sensor layer 2060 to detect keypresses, the keyboard 2000 can be provided without the (separate) keypress sensor layer 2020. This enables the provision of a thin keyboard that is useable both for typing and as a touchpad. This also enables the provision of the touch sensor layer 2060 without holes to enable the passage of the transmittal mechanisms 2030. The lack of a need to provide holes in the touch sensor layer 2060 can simplify manufacture of the touch sensor layer 2060.

In some embodiments, and in particular in embodiments where keypresses are detected using the touch sensor layer 2060, the touch sensor layer 2060 comprises optical elements (e.g. LEDs) arranged to provide a backlight. Where keypresses are detected using the touch sensor layer 2060, holes in the touch sensor layer 2060 for the transmittal mechanisms 2030 are not required; the optical elements may then replace these holes (e.g. so that the optical elements do not overlap with any edges of touch sensor elements). More generally, optical elements may be located on the touch sensor layer 2060 based on the same sets of conditions for the placing of the holes. There may be provided a touch sensor layer 2060 that comprises both holes and optical elements, wherein the locating of the optical elements and the holes is based on the same sets of conditions.

While the detection of a keypress has been described with reference to a capacitive touch sensor, it will be appreciated that such detection is possible with other sensing mechanisms. As an example, a pressure sensor may be used to detect both touches and keypresses, where a light pressure placed on the keys 2002 is indicative of a user providing a touch/pointer input and a heavy pressure placed on the keys 2002 (e.g. a keypress) is indicative of a keystroke input.

Exemplary keyboard constructions where the touch sensor layer 2060 is used to detect keypresses are as follows:

1. The base plate 2010.
2. (optionally) A layer of adhesive.
3. The touch sensor layer 2060.
4. (optionally) The protective layer 2070.
5. The transmittal mechanism 2030.
6. The keypress mechanisms 2040.
7. The keycaps 2050.

and

1. The base plate 2010.
2. (optionally) A layer of adhesive.
3. The touch sensor layer 2060.
4. (optionally) The protective layer 2070.
5. The transmittal mechanism 2030.
6. The keypress mechanism mounting layer (not shown).
7. The keypress mechanisms 2040.
8. The keycaps 2050.

Touch sensor layer

The touch sensor layer 2060 may be any layer that is capable of detecting the position of the finger of a user. The touch sensor layer 2060 may comprise optical sensors, pressure sensors, self-capacitive sensors, and/or mutual capacitance sensors. While the touch sensor layer 2060 is typically described as sensing a touch on the keys of the keyboard 2000, the touch sensor layer may also be arranged to sense an object proximate to the touch sensor layer 2060, where this object may move above the keys 2002 of the keyboard 2000.

As shown in Figure 6a and, in more detail in Figure 7, the touch sensor layer 2060 typically comprises a matrix of electrodes that is used to provide a projected capacitive keyboard. The 'rows' 2062 of electrodes form a transmitting channel, while the 'columns' 2064 of electrodes form a receiving channel. In order to detect a touch, a control unit (not shown) sends a signal sequentially to each of the rows 2062 (so that at any one time only one electrode row is being 'driven'). This results in a signal being induced in the receiving channels/columns 2064. The touch of a user, or the proximity of the coating 2034, alters the local electric field in the vicinity of the electrodes and thereby alters the signal that is induced in each receiving channel/column. For each pair of rows 2062 and columns 2064 there will be a single intersection; therefore, by detecting an alteration in the local electric field for a receiving column based on a driven row, it is possible to detect the precise location of a touch or a keypress.

It will be appreciated other arrangements may be used, e.g. where the columns form the transmitting channel of the touch sensor layer 2060 and the rows form the receiving channel of the touch sensor layer 2060.

In order to detect the alteration in the local electric field, it is necessary to calibrate the touch sensor layer 2060 in order to determine a baseline for the induction in each receiving channel (for each transmitting channel). Differences from this baseline measurement can then be detected. In order to calibrate the touch sensor layer 2060, the signal induced in each column 2064 by a signal being sent to each row 2062 is measured in the absence of a user.

It will be appreciated that a change in the local electric field can be caused simply by proximity to the touch sensor layer 2060; it is not necessary for the user or the coating 2034 to directly impact the touch sensor layer 2060.

In order to distinguish between a keypress and the touch of a user, a control unit which receives signals from the touch sensor layer 2060 may:

- Determine a direction and/or location of movement – typically, the keys will move substantially perpendicular to the touch sensor layer 2060, so that the detection of a substantial parallel movement is useable to identify a user touch and the detection of a substantial perpendicular movement is useable to identify a keypress. Similarly, the keys 2002 will typically be restrained so that each key has a fixed range and location of motion; in contrast a movement across the keyboard (e.g. a user's touch) is unrestrained. Therefore, a keypress may be identified by identifying a specific location/direction of movement.
- Determine a magnitude of a change in the local electric field (e.g. by measuring a current induced in the receiving channels) – typically, the coating 2034 will cause a different (e.g. greater) change in the local electric field than a human finger.
- Determine a rate and/or duration of a change in the local electric field – typically a key is pressed and then released so that the duration of the change in the local electric field may be shorter for a key press than for a finger movement. Similarly, the rate of change of the local electric field may be higher for a key press. Additionally, the depression of a key will

result in a change that increases to a peak. The release of a key will cause a decrease in a similar way. This may not be true for a user's touch.

In some embodiments, the coating 2034 is not provided and the touch sensor layer 2060 is nevertheless used to determine a keypress. Such detection may occur based on the considerations above; in particular a movement of a finger directly towards the touch sensor 2060 (and below the raised level of the keys 2002) may be interpreted as a keypress, while a movement perpendicular to the touch sensor layer 2060 may be interpreted as a touch gesture.

In some embodiments, the control unit of the keyboard 2000 processes signals from the touch sensor layer 2060 in dependence on an input mode of the keyboard 2000. The keyboard 2000 may have a plurality of input modes that can be selected by a user, including a keypress input mode and a pointer input mode. In the keypress input mode, the controller of the touch sensor layer 2060 may expect keypresses, and so detect an isolated capacitive change indicative of a keypress as a keypress. In the pointer input mode, the controller of the touch sensor layer 2060 may expect a user's touch and so may ignore such an isolated change in capacitance, or interpret this change as a touch gesture instead of a keypress.

In some embodiments, the control unit detects keypresses even in the pointer input mode and uses such keypresses as a signal to change to a keypress input mode. Alternatively, the output of pressing a key may differ between the input modes (e.g. the space bar may enter a space when the keyboard is in the keypress input mode and may simulate a mouseclick when the keyboard is in the touchpad input mode).

Exemplary keyboard input modes, and exemplary methods for switching between these input modes, are described in more depth below as well as in WO2019237173 ("INPUT DEVICE, SIGNAL PROCESSING UNIT THERETO, AND METHOD TO CONTROL THE INPUT DEVICE").

Calibration

The touch sensor is typically a capacitive sensor that is arranged to detect the movement of objects above the touch sensor by detecting a change in the local electric field. As has been described above, the touch sensor may also be implemented using, for example, optical cameras and/or pressure sensors.

With each of these embodiments, the operation of the touch sensor is dependent on the componentry surrounding the touch sensor. For example, the operation of the touch sensor may depend on the keys used for the keyboard 2000 and depend on where in the keyboard the touch sensor is located (e.g. whether the touch sensor is located above or below a backlight layer). This componentry is dependent on the keyboard in which the touch sensor is used, where similar touch sensors may be used in a variety of different types of keyboard. For example, similar touch sensors may be used for both low-profile, compact, laptop keyboards and larger desktop keyboards. Equally, similar touch sensors may be used for both simple keyboards with few components and more complex keyboards with backlights and other optional components.

As used herein, componentry typically relates to the (internal) keyboard structure, and in particular to the structure of any components that are between the touch sensor and the user's fingers during the use of the keyboard. In this regard, the operation of the touch sensor depends on features such as the keyboard mechanisms, the transmittal mechanisms, the other layers used etc. Where the touch sensor layer comprises holes, or where any componentry adjacent the touch sensor layer (e.g. the protective layer 2070) comprises holes, the operation of the touch sensor depends on the arrangement of the holes. In particular the operation of the touch sensor is dependent on the protective layer, and on the arrangement of holes in the protective layer.

Due to this dependence on surrounding componentry, there is a risk of the touch sensor providing unexpected or inconsistent outputs. For example, the touch sensor may detect only a small change in the electric field when a user moves their finger from the 'a' key to the 'f' key and then detect a large change in the electric field when the use moves their finger from the 'f' key to the 'g' key. If the user is attempting to scroll across a page, such detection could lead to a jerky scrolling process that starts slowly and then suddenly jumps. Furthermore, there may be an inconsistent response as a user moves their finger across a key, so that a pointer speed may be slow when a user's finger is near the edge of the key and then increase as the user moves their finger towards the centre of the key.

Therefore, referring to Figure 10, there is described a method of calibrating the touch sensor. This method is typically carried out by a user and/or manufacturer of the keyboard. Typically, certain steps of the method are computer-implemented. By calibrating the touch sensor, it is possible to provide a consistent (and predictable) output.

In a first step 11 of the method of calibration, the user provides a touch input at a selected location and in a second step 12, a computer device associated with the touch sensor identifies the resultant signal at the touch sensor.

Where the touch sensor comprises a capacitive touch sensor, the first step 11 and the second step 12 typically involve the user touching the keyboard at a certain location and a processor associated with the touch sensor thereafter determining a change in electric field that is detected by the touch sensor.

In a third step 13, the user determines a difference between the identified signal and an expected signal. The expected signal is associated with the touch input.

In a simple example, the expected input relates to a location of the touch, and the user expects the touch sensor to accurately detect touches at specific locations. The componentry surrounding the touch sensor may affect the detection of touches so that, due to the effects of surrounding componentry, a touch on the 'f' key may be detected by the touch sensor as being a touch that is offset from the 'f' key. In this instance, the difference between the identified signal and the desired signal is the offset.

Typically, the difference comprises a vector that maps an identified touch point to an actual touch point.

The difference may also be related to a magnitude of the identified signal, a direction of the identified signal, and/or a movement of the identified signal. For example, the distance of a gesture from the keyboard (e.g. how far above the keys a user's finger is) is typically determined based on a magnitude of a signal identified by the touch sensor. Therefore, the difference may be related to the difference between an identified magnitude that is detected by the touch sensor and an expected magnitude. The expected magnitude may be selected so that any touch on the keys has the same expected magnitude.

Furthermore, the difference may be based on a movement of a touch input. for example, the user may input a gesture that moves in a single direction and then determine if the identified signal diverges from this single direction.

In a fourth step 14, calibration information based on the difference is output. Typically, the calibration information is determined using a processor (e.g. a processor of the keyboard 2000 and/or a processor of an external computer device to which the keyboard is connected). Outputting the calibration information may then comprise showing the difference to a user, or storing the calibration information in a storage of the keyboard and/or the external computer device so that the difference can be referenced later. Outputting the calibration information may comprise outputting a table of differences relating to different locations of the keyboard.

The keyboard 2000 (or an associated computer device) may reference the calibration information when interpreting a subsequent touch input. In particular, the keyboard may modify a detected signal based on the calibration information and then output the modified signal.

The method of Figure 10 may be performed by a user when the keyboard is received and/or may be performed by a manufacturer of the touch sensor and/or the keyboard before sale to the user.

The differences between the identified signal and the expected signal are typically a result of the componentry of the keyboard 2000, so that it can be beneficial to calibrate the touch sensor once it has been installed in the keyboard. Therefore, this method is typically carried out when the keyboard has been assembled.

Referring to Figure 11 and Figures 12a – 12c, there is described a method of obtaining calibration information, which may be an automated (e.g. computer-implemented) method. This method may form a part of the manufacturing process of the keyboard 2000. The use of an automated calibration process simplifies, and speeds up, the manufacturing of the keyboard and improves the user experience since the touch sensor will work accurately as soon as the user installs the keyboard. This method is typically a computer-implemented method that is carried out by a computer device such as a computer numerical control (CNC) machine.

In a first step 21, the computer device determines a plurality of testing locations for a touch sensor and/or keyboard. This may comprise determining a grid of testing locations, where the computer device (e.g. the CNC machine) can then move along each of the rows and columns of this grid in turn. For example, the computer device may draw a grid over the keyboard with a step of 2mm. It will be appreciated that other sizes of grids may be used and that, even more generally, any arrangement of testing locations may be used (e.g. an irregular arrangement may be used to test the plurality of testing locations).

In some embodiments, the computer device is arranged to determine a plurality of testing locations that covers only a portion of the touch sensor (e.g. a portion associated with two keycaps). These testing locations are then used to infer calibration information for the entirety of the touch sensor. This method is particularly applicable where a regular layout is used for the touch sensor and the keyboard.

In a second step 22, the computer device identifies a signal for the touch sensor at each testing location. The computer device may comprise a conductive material that causes a substantial change in the local electric field as it is passed across the touch sensor. This can simplify the identification of these signals.

An exemplary map of identified signals is shown in Figure 12a, where this map relates to a CNC machine drawing a regular grid over the keyboard. Since the CNC machine has drawn a regular grid over the keyboard, it would be expected that the touch sensor would similarly detect a regular grid; however, as shown by Figure 12a, in practice the signals detected at the touch sensor diverge from the expected signals.

Therefore, in a third step 23, the computer device determines a difference between the identified signal and the expected signal at each of the testing locations. As explained above, the componentry of the keyboard 2000 can cause differences between an intended (or expected) input signal and an identified signal. The differences can be determined based on the signal identified in the touch sensor at each of the testing locations.

Referring to Figure 12b, the differences between the identified signals and the expected signals can be determined by comparing the expected signal and the identified signal at each of the intersections of the grid that is drawn by the computer device. These differences can be stored as vectors and/or as scalar values.

Further differences may be interpolated; for example, the difference for a location that is between two intersections of the grid may be interpolated based on the differences at those intersections.

In a fourth step 24, the computer device outputs the calibration information. This calibration information can thereafter be used to modify a signal detected by the touch sensor before this modified signal is output by the keyboard 2000.

In some embodiments, the computer device determines (and outputs) a plurality of sets of calibration information. In particular, the computer device may determine calibration information for different sets of testing locations (e.g. for both of a 1mm grid and a 1.5mm grid) and output each of these sets of calibration information. A suitable set of calibration information can then be determined when a touch is detected by the touch sensor (at a later date); for example the 1mm grid information may be used when a touch of a stylus is detected and the 1.5mm grid information may be used when a touch of a finger is detected.

Referring to Figure 12c, there is shown a grid of modified signals, where these modified signals relate to a subsequently drawn grid. The modified signals comprise a combination of identified signals (e.g. as shown in Figure 12a) and the differences determined during the calibration method (e.g. as shown in Figure 12b).

It can be seen that the modified signals of Figure 12c are substantially closer to forming the expected grid than the unmodified signals of Figure 12a.

The differences between the identified signals and the expected signals are primarily dependent on the componentry of the keyboard 2000. For example, the keys of the keyboard may interact with the local electric field and thus contribute to the differences. Therefore, different samples of the same product series are typically associated with similar calibration information. This enables the entirety of a production run of a first type of keyboard to be associated with a first set of calibration information and the entirety of a production run of a second type of keyboard to be associated with a second set of calibration information.

While there will be some variation in the differences for each individual keyboard, this variation is typically small. Therefore, the calibration information for a first keyboard of the first type of keyboard can be used for a second keyboard of the first type of keyboard.

In other words, the calibration information for a first keyboard comprising a touch sensor may be determined based on the calibration information for a second, similar, keyboard. This enables calibration to be undertaken on a single keyboard of a product series to obtain calibration information, where this calibration information can then be used for each other keyboard in that product series.

Referring to Figure 13, there is described a method of providing (e.g. manufacturing) a keyboard with calibration information.

In a first step 31, a keyboard with a touch sensor is provided (e.g. as has been described above).

In a second step 32, calibration information for the touch sensor is provided where the calibration information relates a second, similar, keyboard.

In some embodiments, the calibration information relates to a plurality of similar keyboards. In this regard, the calibration information may be determined by testing a plurality of keyboards (as has been described above), where the plurality of calibration information determined for this plurality of keyboards is then combined. For example, the calibration information for each keyboard may be combined by averaging the calibration information determined for each keyboard, or by discarding the minimum or maximum values of the various calibration information. Determining the calibration information using a plurality of keyboards reduces the effect of any abnormalities, for example a manufacturing defect that is present in only a single keyboard.

Therefore, the method of providing a keyboard with calibration information may comprise comprising determining calibration information for a plurality of further keyboards comprising similar touch sensors, combining this calibration information, and associating the combined calibration information with the keyboard. The plurality of further keyboards typically comprise similar keyboards, such as a plurality of keyboards from the same product series). There may be at least two further keyboards, at least five further keyboards, and/or at least ten further keyboards. Combining the calibration information may comprise averaging the calibration information and/or removing extreme (e.g. outlier) values from the calibration information.

Typically, the method of Figure 13 comprises transmitting the calibration information to the keyboard 2000 and/or to a computer device that is associated with the keyboard.

The keyboard 2000 may comprise storage (e.g. flash storage) that enables the keyboard itself to store the calibration information. This enables the keyboard to be sold as a standalone product that is easy to install.

Equally, the calibration information may be provided to an associated computer device. For example, the calibration information may be output to a computer device that is associated with, and/or connected to, the keyboard 2000.

Equally, the calibration information may be provided separately. For example, a kit of parts may be provided that comprises: the keyboard 2000; and a separate device comprising calibration information. The separate device may comprise a USB drive and/or an SD card so that the calibration information can be downloaded onto another computer device.

Yet further, the calibration information may be downloadable so that a purchaser of the keyboard 2000 is able to find the calibration information online and/or is able to update the calibration information if necessary. In some embodiments, the keyboard is arranged to automatically determine the calibration information using the communication interface and the internet (e.g. when the keyboard is connected to a computer device with an internet connection the computer device may automatically download the calibration information).

The previously described methods have considered the determination of differences for a whole keyboard. This enables calibration information to be determined that can be used for an entire product series.

More generally, calibration information may be determined that is dependent on one or more components of the keyboard, e.g. in dependence on the protective layer 2070 above the touch sensor layer 2060. In another example, the use of mechanical switches for the transmittal mechanisms may affect the touch sensor in a first way, and the use of rubber domes for the transmittal mechanisms may also affect the touch sensor in a second way, where the difference between these transmittal mechanisms may be predictable.

By testing different combinations of keyboard components it is possible to predict the effect of a combination of components. Factors (e.g. components) that may affect the operation of the touch sensor include:

- Keycaps.
- Transmittal mechanisms (e.g. whether domes are used, whether mechanical switches are used, which mechanical switches are used).
- Dimensions (e.g. the height of the keycaps and the perimeter of the keyboard).
- The presence, and structure, of a base plate and/or a backlight (or any other layer of the keyboard). In particular, an arrangement of holes in any of the layers may affect the performance of the touch sensor. Such holes may be present, for example, to enable the passage of transmittal mechanisms for the keys.
- The material of the components of the keyboard.
- Defects caused by tooling used for assembling (e.g. recurring defects that occur for each keyboard in a product series).

Often these factors combine in unpredictable ways, and so it is preferable to determine the calibration information for a product series by testing a sample from this product series. However, this may be impractical in certain situations. For example, users may wish to modify the keyboard 2000 after purchase (e.g. to change the keycaps). By determining calibration information for one or more keyboard components the effect of such modifications can be estimated. In practice, a user may be able to modify their keyboard and then to download updated calibration information based on the componentry of the modified keyboard.

The disclosures herein extend to the determining of calibration information for a component of a keyboard and the outputting of this calibration information as well as the determining (e.g.

calculating) of calibration information for a combination of components and the outputting of this calibration information.

Referring to Figure 14, there is described a method of determining calibration information for a keyboard based on a composition of the keyboard 2000. This method is typically performed by a computer device. The method may be performed by the keyboard itself, where the keyboard may be able to determine its own componentry and to select suitable calibration information from a database of calibration information. Equally, the method may be performed by a computer device that is associated with the keyboard.

In a first step 41, the computer device determines the composition (e.g. the components) of the keyboard 2000.

In a second step 42, the computer device determines component calibration information for one or more of the components of the keyboard (e.g. for the keycaps, for the transmittal mechanisms, for any backlight layer, etc.). This component calibration information may be taken from a database of information, which database is formed by testing various combinations of components.

In a third step 43, the computer device determines calibration information for the entirety of the keyboard based on the component calibration information. In a simple example, this may comprise summing the differences associated with each component. It will be appreciated that more complex functions may be used to combine the component calibration information, where these functions may, for example, be determined based on the testing of various combinations of components.

The calibration information for a component of a first keyboard may be determined based on the calibration information determined for a similar component of a second keyboard so that, as described previously, calibration information for a keyboard can be determined based on the calibration of other keyboards.

Referring to Figure 14, there is described a method of operating the keyboard 2000. This method may be performed by the keyboard itself or may be performed by an associated computer device (e.g. a computer device into which the keyboard is plugged).

In a first step 51, the computer device identifies an input touch signal (e.g. a gesture). For example, the input touch signal may be determined by the touch sensor identifying a change in a local electric field.

In a second step 52, the computer device determines calibration information, such as differences. As described previously, the differences may be stored in a database and/or a table of differences. The differences are associated with the composition of the keyboard 2000 so that the differences are typically determined by performing the calibration method of Figure 11 on a different keyboard of the same composition. These differences are then stored on the keyboard for use in this method.

In a third step 53, the computer device modifies the input touch signal based on the calibration information. Typically, this comprises combining the input touch signal with a stored difference to obtain a modified touch signal that closely relates to an actual touch input. For example, where the user has touched the ‘f’ key, the input touch signal may seem to indicate that the user has touched the ‘g’ key instead. The calibration information that is applied to this input touch signal typically comprises a difference, e.g. a vector, that identifies that input signals suggesting a touch on the ‘g’ key actually relate to touches on the ‘f’ key.

In a fourth step 54, the computer device outputs the modified signal. For example, the modified signal may be transmitted to another computer device.

Equally, the computer device may provide an output based on the modified signal. For example, the computer device may determine a gesture performed by a user and/or a location of a gesture performed by a user and consequently perform an action such as scrolling across a page, moving a mouse pointer, displaying a text input, and/or transmitting a signal (e.g. sending an email).

As has been described with reference to Figure 11, the differences are typically determined for a plurality of locations on the keyboard. In practice, a touch input may be identified at a location that is not one of these plurality of locations. In such a situation, the second step 42 of determining the calibration information may comprise one or more of: determining calibration information for a first location based on calibration information for a second location (e.g. where the second location is the closest location for which calibration information has been determined); and determining calibration information for a first location by interpolating and/or extrapolating from calibration information for other locations.

Where a grid of differences is determined (as has been described with reference to Figure 11 and Figures 12a – 12c) calibration information for a first location may be determined by interpolating between calibration information for two or more neighbouring locations.

In this regard, the calibration information typically comprises a table and/or database of datapoints, where each datapoint relates to a different location on the keyboard.

Referring to Figure 16, there is shown an example in which calibration information (e.g. differences) are known for four corners, A, B, C, and D, of a grid square. A touch is detected within this grid square, which touch is located at a touch point P that is a horizontal distance x1 from A and a horizontal distance x2 from B.

The difference at the touch point P may be calculated using a linear interpolation as:

$$\delta_P = \delta_A + (\delta_B - \delta_A)\frac{x1}{x1 + x2}$$

It will be appreciated that this is only a simple example and that more complex (e.g. non-linear) interpolations may be used. Furthermore, the interpolation may be dependent on more than two known differences (e.g. if the touch point is within the grid square of Figure 16 then the difference for the touch point may depend on the differences at each of A, B, C, and D (and/or further differences).

As an example of a more complex interpolation, a bilinear interpolation may be used. For example, the difference at the touch point Q, which is a horizontal distance x1 from A, a horizontal distance x2 from B, a vertical distance y1 from A, and a vertical distance y1 from C, may be calculated using a bilinear interpolation as:

$$\delta_Q = \frac{1}{(x1 + x2)(y1 + y2)}[x2\ x1]\begin{bmatrix} A & C \\ B & D \end{bmatrix}\begin{bmatrix} y2 \\ y1 \end{bmatrix}$$

Alternatives and modifications

It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention.

For example, while calibration information (and differences) has primarily been described in relation to a location of a touch, it will be appreciated that other types of calibration information may be determined. For example, calibration information may be determined for the magnitude of touch signals so as to provide signals that accurately depict the magnitude of a touch input (and thus allow, for example, keypresses and touch inputs to be differentiated).

The keyboard may comprise a standalone keyboard and/or an integrated keyboard, such as the keyboard of a laptop). Where the keyboard is an integrated keyboard, the calibration information is typically determined when the keyboard is installed in the integrated product (e.g. the calibration information may be determined using an assembled laptop).

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

Claims

1. A method of associating calibration information with a keyboard comprising a touch sensor, the method comprising:
   determining calibration information for a further keyboard comprising a similar touch sensor; and
   associating the calibration information with the keyboard.

2. The method of claim 1, wherein the keyboard and the further keyboard are similar keyboards.

3. The method of any preceding claim, comprising determining calibration information for a plurality of further keyboards comprising similar touch sensors, combining this calibration information, and associating the combined calibration information with the keyboard.

4. The method of any preceding claim, wherein the keyboard and the further keyboard comprise the same types of components, preferably wherein the keyboard and the further keyboard comprise the same types of protective plate, with each plate being associated with a corresponding touch sensor, and/or wherein the keyboard and the further keyboard are from the same product series.

5. The method of any preceding claim, comprising determining a variation between the keyboard and the further keyboard; determining modified calibration information based on the calibration information and the variation; and associating the modified calibration information with the keyboard, preferably wherein the variation is associated with a difference in componentry between the keyboard and the further keyboard.

6. The method of any preceding claim, wherein associating the calibration information with the keyboard comprises outputting the calibration information to a storage of the keyboard and/or outputting the calibration information to a separate computer device associated with the keyboard.

7. The method of any preceding claim, wherein the calibration information relates to one or more of: a location; a magnitude; and a direction.

8. The method of any preceding claim, wherein the calibration information relates to a difference between an expected touch signal and a detected touch signal and/or wherein the calibration information is arranged to be combined with a detected touch signal.

9. The method of any preceding claim, wherein determining calibration information comprises determining calibration information for a plurality of points on the further keyboard, preferably a grid of points on the further keyboard.

10. The method of any preceding claim, wherein determining calibration information comprises determining calibration information using a machine, preferably a computer numerical control (CNC) machine.

11. The method of any preceding claim, comprising determining component calibration information for one or more of the components of the further keyboard, preferably determining component calibration information for one or more components of a plurality of further keyboards, and determining the calibration information based on the component calibration information.

12. The method of any preceding claim, comprising assembling the further keyboard.

13. The method of any preceding claim, comprising assembling the keyboard.

14. A method of manufacturing a keyboard comprising: providing a keyboard comprising a touch sensor; and associating calibration information with the keyboard according to the method of any preceding claim.

15. A computer device comprising calibration information for a keyboard that comprises a touch sensor, wherein the calibration information is dependent on a further keyboard comprising a similar touch sensor.

16. The computer device of claim 15, wherein the calibration information has been determined for the further keyboard and thereafter has been associated with the keyboard.

17. The computer device of claim 15 or 16, wherein the further keyboard is a further, similar, keyboard and/or a further keyboard of the same product series as the keyboard.

18. The computer device of any of claims 15 to 17, wherein the computer device is arranged to apply the calibration information to a touch signal detected by the touch sensor.

19. The computer device of any preceding claim, wherein the computer device is arranged to: detect an input touch signal; modify the input touch signal based on the calibration information; and output the modified touch signal.

20. The computer device of claim 19, wherein modifying the input touch signal comprises modifying one or more of: the direction of the touch signal; the magnitude of the touch signal; and the direction of the touch signal.

21. The computer device of claim 19 or 20, wherein modifying the input touch signal based on the comprises modifying the input touch signal based on a datapoint of the calibration information.

22. The computer device of any of claims 19 to 21, wherein modifying the input touch signal comprises modifying the input touch signal based on a plurality of datapoints of the calibration information, preferably modifying the input touch signal based on:

    an interpolated datapoint that is determined based on an interpolation of the plurality of datapoints and/or

    an extrapolated datapoint that is determined based on an extrapolation of the plurality of datapoints.

23. The computer device of claim 22, comprising modifying the input touch signal based on an interpolated datapoint that is determined based on a bilinear interpolation of the plurality of datapoints.

24. A keyboard comprising and/or being the computer device of any of claims 15 to 23.

25. A method of modifying an input touch signal detected by a keyboard comprising a touch sensor, the method comprising:

    detecting an input touch signal;

    modifying the input touch signal based on calibration information; and

    outputting the modified touch signal;

    wherein the calibration information is dependent on a further keyboard comprising a similar touch sensor.

Intellectual Property Office

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Claims searched:	1-25	Date of search:	30 August 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1-25	WO2021/094600 A1 (CLEVETURA LLC; LAHUTSIK YURY ET AL) page 15, lines 15-28, page 16, lines 21-35, page 18, line 37 - page 20, line 18, page 21, line 40 - page 23, line 38, page 31, line 7 - page 32, line 20
Y	1-25	CN113467644 A (MESH TECH CORP) the whole document
A	-	US2008/316184 A1 (D SOUZA HENRY M) paragraphs [0008] - [0012], paragraphs [0019] - [0041]; figures 1-4, paragraphs [0052] - [0057]

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International Classification:

Subclass	Subgroup	Valid From
G06F	0003/023	01/01/2006
G06F	0003/041	01/01/2006