An input interface comprises a touch sensor panel having a surface and a first sensor arrangement provided on the surface to sense a position of a touch action with two-dimensional spatial resolution. A transparent window member is offset from the surface of the touch sensor panel in a direction perpendicular to the surface. A second sensor arrangement is interposed between the surface and the transparent window member. The second sensor arrangement is configured to sense a magnitude of a force normal to the surface applied by the touch action and pushing the window member toward the touch sensor panel.
Touch detected? 81

NO

YES

Determine x,y-coordinates from touch sensor 82

Determine force magnitude from force sensor 83

Control operation of portable electronic device based on x,y-coordinates and force magnitude 84

FIG. 8
INPUT INTERFACE, PORTABLE ELECTRONIC DEVICE AND METHOD OF PRODUCING AN INPUT INTERFACE

FIELD OF THE INVENTION

[0001] The application relates to an input interface, a portable electronic device having an input interface, and a method of producing an input interface. The application relates in particular to input interfaces which include a touch panel sensor configured to sense a touch action with two-dimensional spatial resolution.

BACKGROUND OF THE INVENTION

[0002] Portable electronic devices provide functionalities which continue to be enhanced. With increasing processing capabilities and functionalities provided in the portable electronic device, it is increasingly challenging to provide input interfaces which allow the variety of functionalities to be controlled in an intuitive manner. Touch sensor panels which sense a touch action enhance the ways in which a user may interact with the portable electronic device. Touch sensor panels may be configured such that they provide information on the location at which a user touches a window. Touch sensor panels may be configured to discriminate multi-touch scenarios in which several fingers are used to simultaneously actuate different regions of the touch sensor panel, and/or to track the movement of a user’s finger across the window. detection capabilities allow different functionalities of the portable electronic device to be controlled in a way in which the location of one or plural touch actions, or a movement pattern of the user’s fingers across a window, may encode different control commands. The two-dimensional position(s) of the touch action are the input data which are evaluated to control operation of the portable electronic device.

[0003] One approach to further enhance the operation of the input interface is to derive information on a size of an area at which a user contacts the window of the input interface. The size of this area provides information on the way in which the user places his or her finger against the window. For illustration, the area over which a touch sensor panel will be actuated may vary depending on whether the user pushes more or less strongly against the window, or whether a smaller or larger finger is placed against the window. While this approach does not require a separate sensor and derives additional information from the size of the area at which the window is touched, it has shortcomings. It may be challenging or impossible to discriminate whether a user pushes against the window lightly with his index finger or strongly with his little finger. When a user places a rigid object, such as a pen-type device, against the window, it is inherently difficult to derive information other than the two spatial coordinates defining the position of the touch action with conventional touch sensors.

SUMMARY

[0004] There is a continued need in the art for an input interface, a portable electronic device and a method of producing an input interface which address some of the above shortcomings. In particular, there is a continued need in the art for an input interface, a portable electronic device and a method of producing an input interface which allows additional information on the user’s actuation of the touch panel to be derived. There is also a need for such an input interface which can be manufactured at moderate additional cost.

[0005] According to an embodiment, an input interface is provided. The input interface comprises a touch sensor panel having a surface and a first sensor arrangement provided on the surface to sense a position of a touch action with two-dimensional spatial resolution. The input interface comprises a transparent window member offset from the surface of the touch sensor panel in a direction perpendicular to the surface. The input interface comprises a second sensor arrangement interposed between the surface and the transparent window member; the second sensor arrangement being configured to sense a magnitude of a force normal to the surface applied by the touch action and pushing the window member toward the touch sensor panel.

[0006] The second sensor arrangement may comprise plural conductive traces arranged on the surface of the touch sensor panel.

[0007] The first sensor arrangement may comprise a conductive pattern arranged on a central area of the surface. The plural conductive traces of the second sensor arrangement may be arranged on a peripheral area of the surface which surrounds the central area.

[0008] A spacer area may be formed between the central area and the peripheral area. The spacer area may extend around the central area.

[0009] The first sensor arrangement may comprise other conductive traces arranged on the central area of the surface. The plural conductive traces and the other conductive traces may be formed from the same material. The plural conductive traces and the other conductive traces may be formed simultaneously. The plural conductive traces and the other conductive traces may be formed in the same printing process.

[0010] The input interface may comprise a chip coupled to the conductive pattern to determine the position of the touch action. The chip may be further coupled to the plural conductive traces to determine the magnitude of the force.

[0011] The second sensor arrangement may comprise a force sensing material interposed between the surface and the transparent window member, the force sensing material covering at least two conductive traces of the plural conductive traces. The force sensing material may be applied onto the surface by printing.

[0012] The force sensing material may have a first face contacting the surface and a second face contacting the transparent window member. The force sensing material may bridge the space between the transparent window member and the surface of the touch sensor panel.

[0013] The first face and the second face may be spaced by a height of the force sensing material. A transparent material layer may be interposed between the conductive pattern and the transparent window member, the transparent material layer having another height which is less than or equal to the height of the force sensing material. The transparent material layer may be an optical clear adhesive or ultraviolet (UV) curing adhesive.

[0014] The force sensing material may be resiliently deformable and may have electrical characteristics varying as a function of deformation. The force sensing material may have a resistance which varies as a function of deformation, such that the resistance of the force sensing material between two of the plural conductive traces varies as a function of applied force.
The touch sensor panel may have a first side and a second side, the second side extending parallel to the first side at a first distance. The transparent window member may have another first side and another second side, the second side extending parallel to the other first side at a second distance, the second distance being equal to the first distance.

The touch sensor panel may have a third side and a fourth side, the fourth side extending parallel to the third side at a distance, the third and fourth sides being perpendicular to the first side. The transparent window member may have another third side and another fourth side, the other fourth side extending parallel to the other third side at a fourth distance, the other third and fourth sides being perpendicular to the other first side, and the fourth distance being equal to the third distance.

The touch sensor panel may have an outer boundary and the transparent window member may have another outer boundary, the outer other boundary being flush with the outer boundary. The touch sensor panel and the transparent window may have identical shapes.

The input interface may further comprise a sealing material interposed between the touch sensor panel and the transparent window member. The sealing material may surround the plural conductive traces of the second sensor arrangement and the conductive pattern of the first sensor arrangement. The sealing material may be an optical clear adhesive or a UV curing adhesive. The sealing material may form a ring seal.

The transparent window member and the touch sensor panel may extend parallel to each other. The transparent window member and the touch sensor panel may extend at a distance from each other.

According to another embodiment, a portable electronic device is provided. The portable electronic device comprises a housing having a support area. The portable electronic device comprises an input interface. The input interface comprises a touch sensor panel having a surface and a first sensor arrangement provided on the surface to sense a position of a touch action with two-dimensional spatial resolution. The input interface comprises a transparent window member offset from the surface of the touch sensor panel in a direction perpendicular to the surface. The input interface comprises a second sensor arrangement interposed between the surface and the transparent window member, the second sensor arrangement being configured to sense a magnitude of a force normal to the surface applied by the touch action and pushing the window member toward the touch sensor panel. The touch sensor panel is attached to the support area.

The input interface may be an input interface according to any one embodiment.

The touch sensor panel may have another surface opposite the surface, an outer boundary of the other surface being fastened to the support area.

The touch sensor panel may be interposed between the transparent window member and the support area. The support area may be a shoulder surrounding an opening in the housing of the portable electronic device.

The portable electronic device may further comprise a processing device. The input interface comprises a chip coupled to the conductive pattern to determine the position of the touch action, the chip being further coupled to plural conductive traces of the second sensor arrangement to determine the magnitude of the force applied by the touch action. The processing device may be interfaced with the chip and may be configured to control operation of the portable electronic device as a function of both the position of the touch action and the magnitude of the force applied by the touch action.

The input interface may comprise a flexible printed circuit on which the chip is arranged, the flexible printed circuit having a connector to provide the position of the touch action and the magnitude of the force to the processing device.

According to another embodiment, a method of producing an input interface is provided. First conductive traces are formed on a central area of a surface of a touch sensor panel to provide a first sensor arrangement. The first sensor arrangement is configured to sense a position of a touch action with two-dimensional spatial resolution. Second conductive traces are formed on a peripheral area of the surface to provide a second sensor arrangement. The second sensor arrangement is configured to sense a magnitude of a force applied by the touch action. The peripheral area in which the second conductive traces are formed may surround the central area of the surface. A force sensing material may be applied on the second conductive traces. A transparent window member may be attached to the touch sensor panel such that the transparent window member is offset from the touch sensor panel in a direction normal to the surface and that the second sensor arrangement is interposed between the touch sensor panel and the transparent window member.

The first conductive traces and the second conductive traces may be formed from the same material. The first conductive traces and the second conductive traces may be formed simultaneously. The first conductive traces and the second conductive traces may be formed in the same printing step.

The force sensing material may be applied by printing. The force sensing material may be resiliently deformable. The force sensing material may have electrical characteristics which vary as a function of deformation.

The input interface, portable electronic equipment and method of various embodiments allow a magnitude of a force to be sensed. The force measurement provides additional information, supplementing the x- and y-coordinates defining the position of the touch actuation. The force may be determined even when the user places a rigid object, such as a pen-type device, on the transparent window member. The additional information quantifying the magnitude of the force may be used in controlling operation of a portable electronic device. The ways in which a user may interact with the portable electronic device may thereby be enhanced, using the force of the touch action as an additional source of information. The operation of the portable electronic device may also be controlled in an intuitive way, taking into account the strength at which a user pushes against the transparent window member.

The costs associated with forming the second sensor arrangement are moderate. The second sensor arrangement is interposed between the touch sensor panel and the transparent window member. This allows conductive traces of the second sensor arrangement to be formed efficiently, e.g. in the same processing station in which conductive traces of the first sensor arrangement are also formed.

It is to be understood that the features mentioned above and features yet to be explained below can be used not only in the respective combinations indicated, but also in other combinations or in isolation, without departing from the
scope of the present invention. Features of the above-mentioned aspects and embodiments may be combined with each other in other embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] The foregoing and additional features and advantages of the invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings, in which like reference numerals refer to like elements.

[0033] FIG. 1 is a front view of a portable electronic device according to an embodiment.

[0034] FIG. 2 is a schematic block diagram of the portable electronic device of FIG. 1.

[0035] FIG. 3 is a cross-sectional view through the portable electronic device showing the input interface according to an embodiment in partial cross-sectional view.

[0036] FIG. 4 is a detail view of the input interface in cross-sectional view.

[0037] FIG. 5 is a plan view of a touch sensor panel of a user interface according to an embodiment.

[0038] FIG. 6 is a perspective view showing the combination of touch sensor panel and transparent window member of a user interface according to an embodiment.

[0039] FIG. 7 is a plan view of a touch sensor panel of a user interface according to an embodiment.

[0040] FIG. 8 is a flow chart of a method performed by a portable electronic device according to an embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0041] In the following, embodiments of the invention will be described in detail with reference to the accompanying drawings. It is to be understood that the following description of embodiments is not to be taken in a limiting sense. The scope of the invention is not intended to be limited by the embodiments described hereinafter or by the drawings, which are taken to be illustrative only.

[0042] The drawings are to be regarded as being schematic representations, and elements illustrated in the drawings are not necessarily shown to scale. Rather, the various elements are represented such that their function and general purpose become apparent to a person skilled in the art. Any connection or coupling between functional blocks, devices, components or other physical or functional units shown in the drawings or described herein may also be implemented by an indirect connection or coupling. A coupling between components may also be established over a wireless connection. Functional blocks may be implemented in hardware, firmware, software or a combination thereof. While portable electronic devices having an input interface of an embodiment may be wireless communication devices, personal digital assistants, or other portable devices having communication capabilities, the input interface is not limited to being used in such communication devices.

[0043] The features of the various embodiments may be combined with each other unless specifically noted otherwise.

[0044] Portable electronic devices having an input interface will be described. The input interface has a first sensor arrangement to detect a position of a touch action in a spatially resolved manner. The first sensor arrangement is operative as a touch sensor. The input interface additionally has a second sensor arrangement separate from the first sensor arrangement and configured to sense a magnitude of a force applied by the touch action. The second sensor arrangement is interposed between a transparent window member and a touch sensor panel. As will be described in more detail with reference to the drawings, the second sensor arrangement may have a plurality of conductive traces and a resiliently deformable force sensing material.

[0045] FIG. 1 is a front view of a portable electronic device 1 and FIG. 2 is a schematic block diagram representation of the portable electronic device 1. The portable electronic device 1 has an input interface 3. The input interface 3 includes a first sensor arrangement to sense the position of a touch action on the input interface, and a second sensor arrangement to sense a force applied by the touch action. The input interface 3 may include a display, thereby implementing a touch-sensitive screen. The portable electronic device 1 has a processing device 4 coupled to the input interface 3. The processing device 4 may be one processor or may include plural processors, such as a main processor 11 and a graphics processing unit 12. The processing device 4 may perform processing and control operations. The processing device 4 may be configured such that, at least in some modes of operation, it controls operation of the portable electronic device 1 based on both a position of a touch action and a force applied by the touch action. The processing device 4 may control operation of the portable electronic device 1 in accordance with instruction code stored in a memory 5.

[0046] The portable electronic device 1 may be operative as a portable communication device, e.g., a cellular telephone, a personal digital assistant, or similar. The portable electronic device 1 may include components for voice communication, which may include a microphone 6, a speaker 7, and a wireless communication interface 9 for communication with a wireless communication network. In addition to the input interface 3, the portable electronic device 1 may have separate hard keys 8, such as function and/or control keys.

[0047] With reference to FIG. 3 to FIG. 7, the configuration and operation of the input interface 3 will be explained in more detail.

[0048] FIG. 3 shows a partial cross-sectional view through the portable electronic equipment along line III-III in FIG. 1.

[0049] The user interface 3 is arranged in an opening of a housing 10 of the portable electronic device 1. The housing 10 may consist of plural components, such as a first shell 13, a second shell 14, and an intermediate wall 15 which are attached to each other. The first shell 13 defines an opening in which the input interface 3 is arranged. At a periphery of the opening, the first shell 13 has a support area 16. The support area 16 supports the input interface 3. The support area 16 also serves as a force support area which provides a counter-force acting onto the input interface 3 when the user presses against the input interface 3.

[0050] The input interface 3 generally has a touch sensor panel 21 and a transparent window member 22. A surface 30 of the touch sensor panel 21 faces toward the transparent window member 22. The transparent window member 22 is offset from the surface 30 in a direction perpendicular to the surface 30. Accordingly, the transparent window member 22 and the touch sensor panel 21 extend parallel to each other and at a distance from each other. On the surface 30, a first sensor arrangement is formed. The first sensor arrangement is configured to sense a position of a touch action in a spatially resolved manner in two spatial dimensions. The first sensor arrangement may be configured to provide information on the
x- and y-coordinates at which the user pushes against the input interface 3. The first sensor arrangement may be configured as a capacitive or resistive touch sensor, for example. A second sensor arrangement is arranged on the surface 30. The second sensor arrangement may include a plurality of conductive traces which are located on the surface 30. The plurality of conductive traces allows electrical characteristics of a force sensing material 43 to be measured. The force sensing material 43 is interposed between the touch sensor panel 21 and the transparent window member 22. The force sensing material 43 bridges the gap between the touch sensor panel 21 and the transparent window member 22. The force sensing material 43 may contact both the touch sensor panel 21 and the transparent window member 22. When the force sensing material 43 is deformed in response to the force exerted onto the user interface 3, the plurality of conductive traces allow the resultant change in electrical characteristics to be measured. The magnitude of the force can be derived from the electrical characteristics or the change in electrical characteristics. For illustration, a resistance between a pair of conductive traces of the first sensor arrangement may be measured. The resistance may change as a function of density of the force sensing material 43 which is overlaid on the pair of conductive traces.

The first sensor arrangement is located at a peripheral area of the surface 30. The plural conductive traces of the second sensor arrangement which are used to measure the magnitude of the force and other conductive traces of the first sensor arrangement may be spatially separated. The plural conductive traces of the second sensor arrangement may be made from the same material as the other conductive traces of the first sensor arrangement. The conductive traces of the first sensor arrangement and the plurality of conductive traces of the second sensor arrangement may be made from silver.

The transparent window member 22 may be attached to the housing 10 via the touch sensor panel 21. The touch sensor panel 21 may be interposed between the transparent window member 22 and the support area 16 at which the input interface 3 is attached to the housing 10. The touch sensor panel 21 may be fastened to the support area 16 by an adhesive material 24. The adhesive material 24 may be a double adhesive tape, for example. The adhesive material 24 may be less resistant than the force sensing material 43. A bulk modulus of the adhesive material 24 may be greater than a bulk modulus of the force sensing material 43.

A transparent layer 25 of material may be arranged between a central area of the surface 30 and the transparent window member 22. The layer 25 may be made from optical clear adhesive or a UV curing adhesive. A sealing material 26 may be arranged at an outer boundary of the surface 30 between the touch sensor panel 21 and the transparent window member 22. The sealing material 26 may also be optical clear adhesive or a UV curing adhesive. The sealing material 26 and the transparent layer 25 may be formed simultaneously when the input interface 3 is produced.

The input interface 3 may also include a display 23. The display 23 may be a liquid crystal display. The display 23 may be attached to the touch sensor panel 21 by an adhesive layer 27. The layer 27 may be made from optical clear adhesive or a UV curing adhesive. An air gap 29 may be formed in an interior of the housing adjacent the display 23 between the display 23 and the intermediate member 15. A protective layer 28 may be applied on an outer surface of the transparent window member 22. The configuration of the input interface 3 and configurations of the first and second sensor arrangements will be described in more detail with reference to FIG. 4 to FIG. 7.

FIG. 4 shows a portion of the input interface 3 indicated at 19 in FIG. 3 as an enlarged partial cross-sectional view. The first sensor arrangement detects a location at which the input interface 3 is actuated. The first sensor arrangement may be configured as a capacitive touch sensor or as a resistive touch sensor. The first sensor arrangement includes a conductive pattern 31 which is arranged on a central area of the surface 30. The conductive pattern 31 may be arranged such that it overlays the display 23. The conductive pattern may be a diamond-shaped pattern. The conductive pattern 31 may be formed from a transparent material, such as indium tin oxide (ITO), graphene, or another transparent material. Alternatively or additionally, the conductive pattern 31 may be formed such that it does not obstruct the light emitted from pixels of the display 23. For illustration, the conductive pattern 31 may include thin strips of conductive material which are arranged such that they are located above the boundary of adjacent pixels of the display 23. The conductive pattern 23 then does not have to be formed from a transparent material. The conductive pattern 23 allows light emitted from the display 23 to be seen in a visible area 18 of the input interface.

The first sensor arrangement may include conductive traces 32. The conductive traces 32 may connect the conductive pattern 31 to an integrated semiconductor circuit, such as a chip. The conductive traces 32 may be arranged in the central area of the surface 30, but may be offset from a visible area 18 in a direction parallel to the surface 30. The visible area 18 is the area in which the light output by the display 23 is transmitted to the user. The layer 25 of transparent material may be arranged as an overlay of the conductive pattern 31 and the conductive traces 32. The layer 25 may have a height or thickness, measured normal to the surface 30, which is less than or equal to a height or thickness of the force sensing material 43.

The second sensor arrangement includes a plurality of conductive traces 41, 42. More than two conductive traces 41, 42 may be used. The plurality of conductive traces 41, 42 is formed on the surface 30 of the touch sensor panel 21. The plurality of conductive traces 41, 42 may be formed in an outer peripheral region of the surface 30. The plurality of conductive traces 41, 42 may be formed in a region of the surface 30 which overlays the support area 16 of the housing.

A force applied to the input interface 3 in a touch action pushes the transparent window member 22 toward the touch sensor panel 21. The transparent window member 22 may be displaced relative to the touch sensor panel 21. Alternatively or additionally, the transparent window member 22 and/or the touch sensor panel may deform in response to the applied force. The resulting displacement or deformation causes the force sensing material 43 to deform resiliently. A resultant change in electrical characteristics may be sensed via the plurality of conductive traces 41, 42. The resultant change allows the magnitude of the force 20 to be determined quantitatively.

For illustration rather than limitation, the force sensing material 43 may be an ink. The force sensing material 43 may have a resistance which changes as the force sensing material 43 becomes compressed. Other measurement techniques may be used, such as capacitive sensing which is
responsive to a change in dielectric constant of the material interposed between a pair of conductive traces as the force sensing material 43 is compressed.

[0063] The conductive traces 32 of the first sensor arrangement and the plurality of conductive traces 41, 42 of the second sensor arrangement may be made from the same material. For illustration, the conductive traces 32 of the first sensor arrangement and the plurality of conductive traces 41, 42 of the second sensor arrangement may be silver conductive traces. The conductive traces 32 of the first sensor arrangement and the plurality of conductive traces 41, 42 of the second sensor arrangement may be formed in the same processing step, e.g. when conductive traces are printed onto the touch sensor panel 21 when producing the input interface 3.

[0064] The conductive traces 32 of the first sensor arrangement may also be arranged in plural different planes. Some of the conductive traces 32 of the first sensor arrangement may be located directly on the surface 30, while some other conductive traces 32 may be located in a plane offset from the surface 30, in between the surface 30 and the transparent window member 22. Thereby, a layered structure of conductive traces may be formed, with the conductive traces 32 of the first sensor arrangement being located in different planes and insulating material being arranged between the planes. Alternatively or additionally, the plurality of conductive traces 41, 42 of the second sensor arrangement may also be arranged in different planes. A layered structure may be formed in which the plurality of conductive traces 41, 42 of the second sensor arrangement extends in plural different planes. Insulating material may be disposed between the planes.

[0065] If the conductive traces 32 of the first sensor arrangement and/or the conductive traces 41, 42 of the second sensor arrangement are located in different planes, there may be at least one plane in which both some conductive traces 32 of the first sensor arrangement and some conductive traces 41, 42 of the second sensor arrangement are located. Such conductive traces lying in the same plane may be formed simultaneously. If there are plural planes in which some conductive traces 32 of the first sensor arrangement and some conductive traces 41, 42 of the second sensor arrangement are located, these conductive traces lying in the same plane may respectively be formed simultaneously.

[0066] Not only the printing of conductive traces 32 of the first sensor arrangement and of conductive traces 41, 42 of the second sensor arrangement may be performed in parallel, but also other processing. For illustration, if insulating layers are to be applied both on some conductive traces 32 of the first sensor arrangement and on conductive traces 41, 42 of the second sensor arrangement, the insulating layers may be applied simultaneously. This allows the second sensor arrangement to be formed in parallel with the first sensor arrangement when the input interface is produced.

[0067] One integrated semiconductor circuit, e.g. one chip, may be used both for determining the position of the touch action based on data retrieved using the first sensor arrangement and the magnitude of the force applied by the touch action based on data retrieved using the second sensor arrangement. The chip of a touch panel sensor may be reconfigured so as to perform force measurements using the second sensor arrangement. The chip may be a touch sensor panel chip which is electrically connected to the plurality of conductive traces of the second sensor arrangement, i.e., of the force sensor. A firmware upgrade may be performed to configure the chip to perform force sensing operations, in addition to sensing information on a position of a touch action.

[0068] FIG. 5 is a plan view of a touch sensor panel 21 of an input interface according to an embodiment. The touch sensor panel 21 may be used in the input interface 3 of the portable electronic device 1 of FIG. 1 and FIG. 2.

[0069] The surface 30 of the touch sensor panel which faces toward the transparent window member 22 has a central area 35 on which the first sensor arrangement for sensing the position of the touch action is provided. A conductive pattern 31 is formed on a portion 36 of the central area 35. The portion 36 with the conductive pattern 31 formed thereon may be overlaid on a display. The conductive pattern 31 may be formed from various conductive materials or combinations of conductive materials, such as indium tin oxide (ITO), graphene, or other materials suitable for forming resistive or capacitive touch sensors. The conductive pattern 31 may extend throughout the portion 36. The conductive pattern 31 may be a diamond-shaped pattern.

[0070] Conductive traces 32 of the first sensor arrangement are located on another portion 37 of the central area 35. The other portion 37 may surround the portion 36 on which the conductive pattern 31 is formed. The conductive traces 32 are electrically coupled to the conductive pattern 31 and a chip 51. While only a limited number of conductive traces 32 are shown, the number of conductive traces 32 of the first sensor arrangement may be rather large to provide good spatial resolution of position sensing. For illustration, if the conductive pattern 31 includes a first plurality of rows and a second plurality of columns, there may be at least one conductive trace 32 for each row and at least one conductive trace 32 for each column of the conductive pattern 31.

[0071] The touch sensor panel 21 extends beyond the central area 35. The peripheral area 38 of the surface 30 of the touch sensor panel 21 extends at an outer side of the central area 35. The peripheral area 38 may completely surround the central area 35 to allow force sensing to be performed at all sides of the input interface. In other implementations, the peripheral area 38 may extend at an outer side of the central area 35 only along some of the edges of the touch sensor panel 21.

[0072] The peripheral area 38 supports the second sensor arrangement which is configured to perform force sensing. The second sensor arrangement comprises a plurality of conductive traces 41, 42 which are formed on the peripheral area 38. The plurality conductive traces 41, 42 may be formed externally of the portion 36 overlaid on the display 23. The conductive traces 41, 42 are then not overlaid on the display 23. A force sensing material may be provided to cover at least a pair of conductive traces 41, 42. The force sensing material may be applied along a line which surrounds the central area 35 of the touch sensor material. The force sensing material may also be applied locally, e.g. along a portion of the peripheral area 38 which extends along a longitudinal side 61 of the touch sensor panel 21, along another portion of the peripheral edge 38 which extends along transverse side 64 of the touch sensor panel 21, and/or along another portion of the peripheral area 38 which extends along the opposite longitudinal side 62.

[0073] The plurality of conductive traces 41, 42 of the second sensor arrangement may be connected to the same chip 51 which also evaluates signals retrieved over the conductive traces 31 of the first sensor arrangement. The chip 51
is an integrated semiconductor circuit which may perform operations of both detecting a position of a touch action and sensing a force magnitude based on signals on the conductive traces 41, 42. Other configurations using a dedicated chip for the force sensing may be used in other embodiments.

[0074] The chip 51 is provided on a flexible printed circuit 50. The flexible printed circuit 50 also has conductive connections for the force sensing operation. A connector 52 is formed on the flexible printed circuit 50 to interface the chip 51 with the processing device 4 of the portable electronic device 1 in which the input interface is used. The chip 51 may provide information representing the location(s) at which a touch action occurs to the processing device 4 over the connector 52. The chip 51 may additionally provide information representing the magnitude of the force applied by the touch action to the processing device 4.

[0075] The conductive traces 32 of the first sensor arrangement and the plurality of conductive traces 41, 42 of the second sensor arrangement are both provided on the same surface of the touch sensor panel 21. This allows the second sensor arrangement to be formed in a cost-efficient manner. For illustration, the plurality conductive traces 41, 42 of the second sensor arrangement and the conductive traces 31, 32 of the first sensor arrangement may both be formed by printing. The plurality conductive traces 41, 42 of the second sensor arrangement and the conductive traces 31, 32 of the first sensor arrangement may be formed in one printing process. The plurality conductive traces 41, 42 of the second sensor arrangement and the conductive traces 31, 32 of the first sensor arrangement may be formed simultaneously. The force sensing material may be applied on the plurality of conductive traces 41, 42 of the second sensor arrangement. The force sensing material may be an ink having electrical characteristics that vary as a function of density. One example for such a material is an ink with trade name UNEO, available from UCCTW. There is a variety of other resiliently deformable materials which may be used as force sensing material.

[0076] A ring seal made of optical clear adhesive or another sealing material, such as UV curing adhesive, may be applied around the peripheral area 38.

[0077] The second sensor arrangement which is operative to perform force sensing is interposed between the touch sensor panel 21 and the transparent window member 22. The lateral dimensions of the touch sensor panel 21 may be matched to the lateral dimensions of the transparent window member 22. The touch sensor panel 21 may have the same area as the transparent window member 22.

[0078] FIG. 5 and FIG. 6 illustrate dimensions of the touch sensor panel 21 and the transparent window member 22. Longitudinal sides 61, 62 of the touch sensor panel 21 are spaced by a first distance 65, which corresponds to the width of the touch sensor panel 21. Longitudinal sides 71, 72 of the transparent window member 22 are spaced by a second distance 75, which corresponds to the width of the transparent window member 22. The first distance 65 and the second distance 75 may be equal. I.e., the touch sensor panel 21 and the transparent window member 22 may have identical widths.

[0079] Alternatively or additionally, the lengths of the touch sensor panel 21 and the transparent window member 22 may be matched to one another. Transverse sides 63, 64 of the touch sensor panel 21 are spaced by a third distance 66, which corresponds to the length of the touch sensor panel 21. Transverse sides 73, 74 of the transparent window member 22 are spaced by a fourth distance 76, which corresponds to the length of the transparent window member 22. The third distance 66 and the fourth distance 76 may be equal. I.e., the touch sensor panel 21 and the transparent window member 22 may have identical lengths.

[0080] The touch sensor panel 21 and the transparent window member 22 do not need to have rectangular shapes. The sizes and shapes of the touch sensor panel 21 and the transparent window member 22 may be matched to one another also when the shape of the touch sensor panel 21 and of the transparent window member 22 is not rectangular.

[0081] The dimensions of the touch sensor panel 21 and of the transparent window member 22 do not need to fully coincide. Different shapes and/or dimensions may be used, as long as the second sensor arrangement can be interposed between the touch sensor panel 21 and the transparent window member 22, and the touch sensor panel 21 may be fastened to the support area 16 of the housing. In particular, small differences in shapes of the outer boundary of the touch sensor panel 21 and of the outer boundary of the transparent window member 22 are tolerable.

[0082] The second sensor arrangement may include more than one force sensor to perform force sensing at various locations around the periphery of the input interface. The force sensing may be performed at locations which are spaced from the corners of the input interface. The force sensing may be performed at central regions of the longitudinal and/or transverse edges of the input interface.

[0083] FIG. 7 is a plan view of a touch sensor panel 21 of an input interface according to an embodiment in which the second sensor arrangement has several force sensors. The touch sensor panel 21 may be used in the input interface 3 of the portable electronic device 1 of FIG. 1 and FIG. 2.

[0084] The second sensor arrangement comprises a first force sensor having a first pair of conductive traces 41, 42 and a force sensing material 43 applied thereon. The first force sensor senses a force at a longitudinal edge of the input interface. The second sensor arrangement comprises a second force sensor having a second pair of conductive traces 44, 45 and a force sensing material 46 applied thereon. The second force sensor senses a force at an opposite longitudinal edge of the input interface. The second sensor arrangement comprises a third force sensor having a third pair of conductive traces 47, 48 and a force sensing material 49 applied thereon. The third force sensor senses a force at a transverse edge of the input interface.

[0085] The conductive traces 41, 42, 44, 45, 46 and 47 are all connected to the chip 51. In embodiments, different force sensors may share one of the conductive traces. This conductive trace may correspond to ground, for example.

[0086] Various techniques may be used to derive information on the spatial distribution of the force acting onto different regions of the input interface from the electrical signals sensed over the conductive traces. For illustration, force sensing material having electrical characteristics which vary as a function of resilient deformation may be applied locally in certain regions, to thereby increase the spatial sensitivity of the force sensing. Alternatively or additionally, the distance between pairs of conductive traces which form a force sensor may be smaller in a region in which the respective force sensor is intended to be sensitive. Distances between conductive traces of the second sensor arrangement may therefore vary along the peripheral area 38. Alternatively or additionally, even when the force sensing material is applied on the
plurality of conductive traces so as to cover the plurality of conductive traces throughout the peripheral area 38, information on the forces pushing the transparent window member 22 toward the touch sensor panel 21 at the various edges of the input interface may be derived from calibration data. For illustration, the chip 51 may perform a lookup operation to determine the magnitudes of forces acting at the various edges based on the signals received from plural force sensors. Information on the position of the touch action determined by the first sensor arrangement may be utilized to derive the distribution of the forces acting at various edges of the input interface.

[0087] When the second sensor arrangement has plural force sensors, the operation of the input interface 3 is enhanced further. For illustration, the force magnitudes sensed by the plural force sensors may be combined with each other to determine the total force. Alternatively or additionally, the force magnitudes sensed by the plural force sensors may be used to verify information on a location of a touch action. Alternatively or additionally, the force magnitudes sensed by the plural force sensors may be combined with the position information captured using the first sensor arrangement to discriminate different types of touch actions, such as one finger versus plural fingers.

[0088] The input interface allows a force magnitude to be captured in addition to information on a position at which a touch action occurs. Operation of the portable electronic device 1 in which the input interface is used may be controlled based not only on the location of the touch action, but also based on the force magnitude.

[0089] FIG. 8 is a flow chart of a method 80 which may be performed by the processing device 4 of the portable electronic device 1 which has the input interface according to an embodiment.

[0090] At 81, it is determined whether there is a touch action at the user interface. The monitoring at 81 is continued if there is no touch action. If a touch action is detected, at 82, information on the position at which the touch action occurs is determined based on information captured using the first sensor arrangement which operates as a touch sensor. The information on the position may include x- and y-coordinates of the touch action. In parallel, at 83 the force magnitude is determined based on data captured using the second sensor arrangement which operates as a force sensor.

[0091] At 84, the operation of the portable electronic device is controlled based on both the information on the position and the force magnitude. This may be done in various ways, depending on processes which are presently being carried out by the portable electronic device. For illustration, when scrolling through a document, the scroll direction may be determined based on the x- and y-coordinates of the touch action, while the scroll speed may be set based on the sensed force magnitude. In a shuffle operation, the list of media items in which shuffling is performed may be selected based on the x- and y-coordinates of the touch action, while the degree of randomization may be set based on the sensed force magnitude. In a media player mode, a fast forward or fast backward operation may be selectively performed based on the x- and y-coordinates of the touch action, while the speed of the fast forward, for example, is set based on the sensed force magnitude. In an operation in which a user sets a number in the portable electronic device, such as time of a timer, the number may be selectively increased or decreased based on the x- and y-coordinates of the touch action, while the increment or decrement may be determined by the sensed force magnitude. There is a wide variety of other scenarios in which the force magnitude provides additional control functions, which allow the user to control operation of the portable electronic device in an intuitive way.

[0092] When the operation of the portable electronic device is controlled based on the force magnitude, a discretization may be used. For illustration, the sensed force magnitude may be compared to a plurality of force values to determine which action is to be taken.

[0093] When the operation of the portable electronic device is controlled based on the force magnitude, the monitoring of the force may be continued during an ongoing touch action. This allows a user to keep a finger or pointing device in engagement with the surface, while controlling the operation over the force magnitude.

[0094] While input interfaces, portable electronic devices and methods have been described with reference to the drawings, modifications and alterations may be implemented in further embodiments. For illustration, while the second sensor arrangement operative to sense a force magnitude may include a pair of conductive traces and a force sensing material applied thereon, other implementations of the force sensor are possible. For illustration, the force sensing material may itself include a combination of a resilient conductor with electrically conductive members arranged therein at certain heights above the surface of the touch sensor panel.

[0095] For further illustration, while certain implementations of the first sensor arrangement which detects the position of a touch action were described, other implementations of the first sensor arrangement may be used. For illustration, the conductive pattern may be formed from a material other than ITO. A pattern different from a diamond pattern may be used. The first sensor arrangement may be operative as a resistive or capacitive touch sensor, for example.

[0096] Although the invention has been shown and described with respect to certain preferred embodiments, equivalents and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalents and modifications and is limited only by the scope of the appended claims.

1. An input interface, comprising:
   a touch sensor panel having a surface and a first sensor arrangement provided on the surface to sense a position of a touch action with two-dimensional spatial resolution;
   a transparent window member offset from the surface of the touch sensor panel in a direction perpendicular to the surface; and
   a second sensor arrangement interposed between the surface and the transparent window member, the second sensor arrangement being configured to sense a magnitude of a force normal to the surface applied by the touch action and pushing the window member toward the touch sensor panel.

2. The input interface of claim 1,
   the second sensor arrangement comprising plural conductive traces arranged on the surface of the touch sensor panel.

3. The input interface of claim 2,
   the first sensor arrangement comprising a conductive pattern arranged on a central area of the surface,
the plural conductive traces of the second sensor arrangement being arranged on a peripheral area of the surface which surrounds the central area.

4. The input interface of claim 3, a spacer area being formed between the central area and the peripheral area, the spacer area extending around the central area.

5. The input interface of claim 3, the first sensor arrangement comprising other conductive traces arranged on the central area of the surface, the plural conductive traces and the other conductive traces being formed from the same material.

6. The input interface of claim 3, further comprising: a chip coupled to the conductive pattern to determine the position of the touch action, the chip being further coupled to the plural conductive traces to determine the magnitude of the force.

7. The input interface of claim 2, the second sensor arrangement comprising a force sensing material interposed between the surface and the transparent window member, the force sensing material covering at least two conductive traces of the plural conductive traces.

8. The input interface of claim 7, the force sensing material having a first face contacting the surface and a second face contacting the transparent window member.

9. The input interface of claim 8, the first face and the second face being spaced by a height of the force sensing material, a transparent material layer being interposed between the conductive pattern and the transparent window member, the transparent material layer having another height which is less than or equal to the height of the force sensing material.

10. The input interface of claim 7, the force sensing material being resiliently deformable and having electrical characteristics varying as a function of deformation.

11. The input interface of claim 1, the touch sensor panel having a first side and a second side, the second side extending parallel to the first side at a first distance, the transparent window member having another first side and another second side, the other second side extending parallel to the other first side at a second distance, the second distance being equal to the first distance.

12. The input interface of claim 11, the touch sensor panel having a third side and a fourth side, the fourth side extending parallel to the third side at a third distance, the third and fourth sides being perpendicular to the first side, the transparent window member having another third side and another fourth side, the other fourth side extending parallel to the other third side at a fourth distance, the other third and fourth sides being perpendicular to the other first side, the fourth distance being equal to the third distance.

13. The input interface of claim 1, the touch sensor panel having an outer boundary and the transparent window member having another outer boundary, the other outer boundary being flush with the outer boundary.

14. The input interface of claim 13, further comprising: a sealing material interposed between the touch sensor panel and the transparent window member, the sealing material surrounding the surface of the touch sensor panel.

15. A portable electronic device, comprising: a housing having a support area; and an input interface, the input interface comprising: a touch sensor panel having a surface and a first sensor arrangement provided on the surface to sense a position of a touch action with two-dimensional spatial resolution; a transparent window member offset from the surface of the touch sensor panel in a direction perpendicular to the surface; and a second sensor arrangement interposed between the surface and the transparent window member, the second sensor arrangement being configured to sense a magnitude of a force normal to the surface applied by the touch action and pushing the window member toward the touch sensor panel; the touch sensor panel being attached to the support area.

16. The portable electronic device of claim 15, the touch sensor panel having another surface opposite the surface, an outer boundary of the other surface being fastened to the support area.

17. The portable electronic device of claim 15, further comprising: a processing device; the input interface comprising a chip coupled to the conductive pattern to determine the position of the touch action, the chip being further coupled to plural conductive traces of the second sensor arrangement to determine the magnitude of the force; the processing device being interfaced with the chip and being configured to control operation of the portable electronic device as a function of both the position of the touch action and the magnitude of the force.

18. The portable electronic device of claim 17, the input interface comprising a flexible printed circuit on which the chip is arranged, the flexible printed circuit having a connector to provide the position of the touch action and the magnitude of the force to the processing device.

19. A method of producing an input interface, the method comprising: forming first conductive traces on a central area of a surface of a touch sensor panel to provide a first sensor arrangement to sense a position of a touch action with two-dimensional spatial resolution; forming second conductive traces on a peripheral area of the surface to provide a second sensor arrangement to sense a magnitude of a force applied by the touch action, the peripheral area surrounding the central area of the surface, applying a force sensing material on the second conductive traces; and attaching a transparent window member to the touch sensor panel such that the transparent window member is offset from the touch sensor panel in a direction normal to the surface and that the second sensor arrangement is interposed between the touch sensor panel and the transparent window member.
20. The method of claim 19, the first conductive traces and the second conductive traces being formed from the same material, the first conductive traces and the second conductive traces being formed simultaneously.