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(12) **United States Patent**
Ludwig

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(54) **TOUCH SCREEN METHOD FOR RECOGNIZING A FINGER-FLICK TOUCH GESTURE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(51) **Int. Cl.**
G06F 3/041 (2006.01)

(52) **U.S. Cl.**
USPC **345/173**; 178/18.01

(58) **Field of Classification Search**
USPC 345/173–176; 178/18.01–19.03; 382/124, 126
See application file for complete search history.

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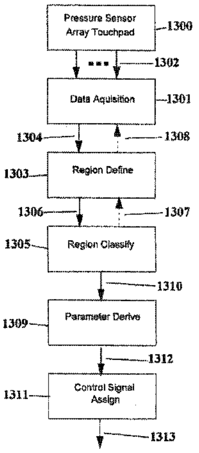
(57) **ABSTRACT**

A touch screen method for recognizing a finger-flick touch gesture for an electronic device including a overlaying a plurality of transparent sensors on top of a visual display associated with the electronic device and where the transparent sensors are configured to be responsive to touch by at least one user finger and the visual display is for rendering visual information provided by the electronic device is disclosed. Control parameters associated with sensor measurements include parameter derived from recognizing a finger-flick touch gesture.

25 Claims, 7 Drawing Sheets



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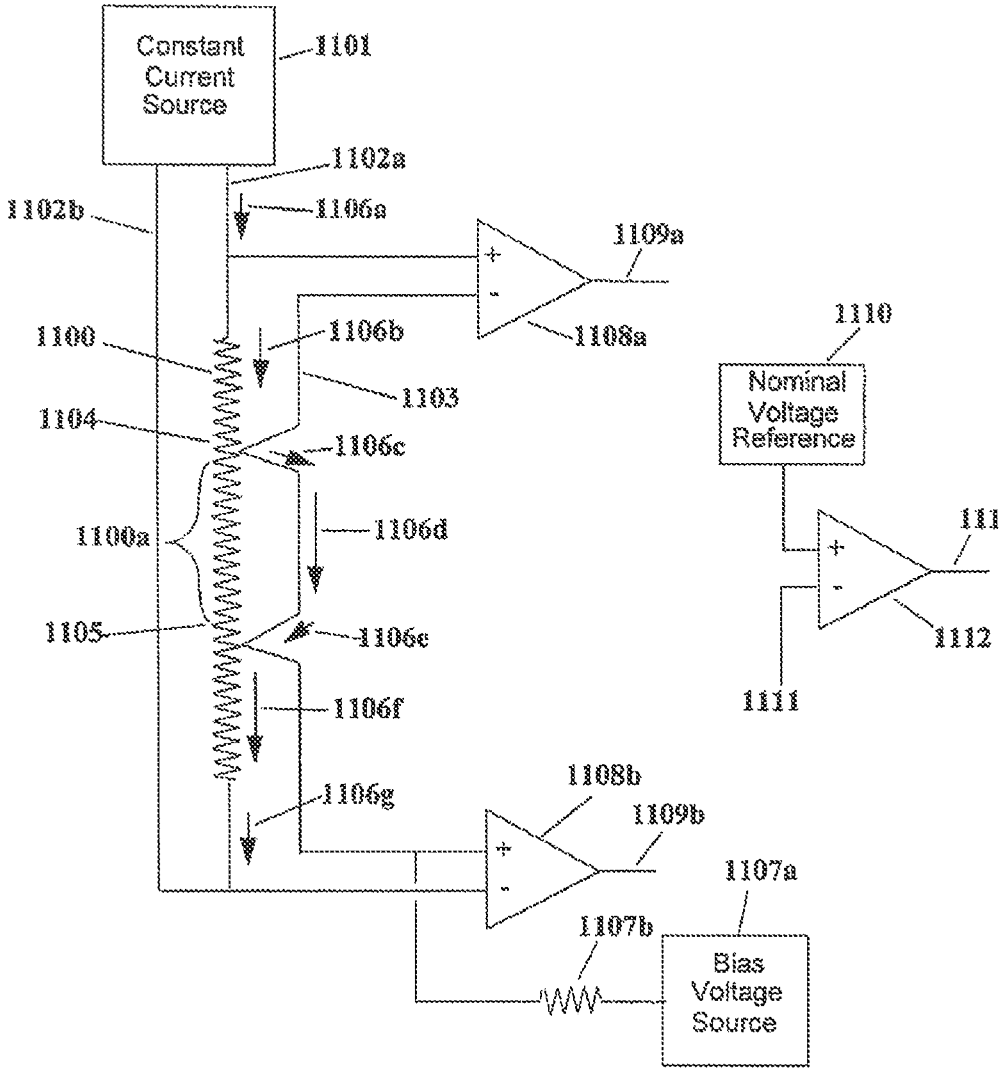
Constant Current Source
1101
1102a
1102b
1106a
1109a
+
-
1108a
1100
1106b
1103
1104
1106c
1100a
1106d
1105
1106e
1106f
1106g
1108b
1109b
1107a
1107b
Bias Voltage Source
1110
Nominal Voltage Reference
1113
1112
1111

Figure 1

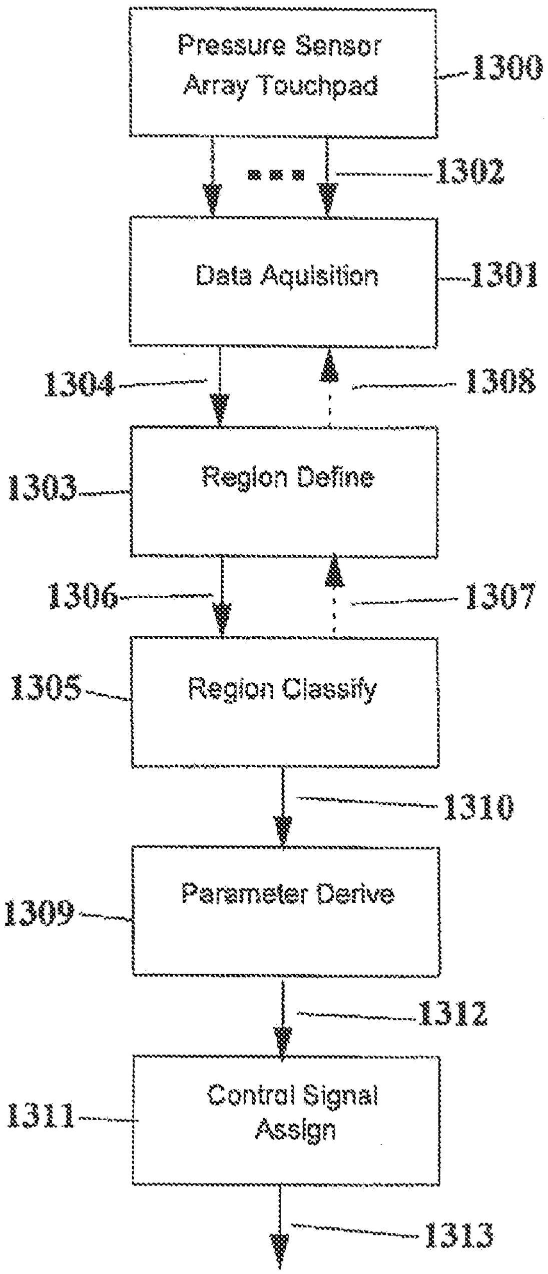
Pressure Sensor Array Touchpad
1300
1302
Data Aquisition
1301
1304
1308
Region Define
1303
1306
1307
Region Classify
1305
1310
Parameter Derive
1309
1312
Control Signal Assign
1311
1313

Figure 2

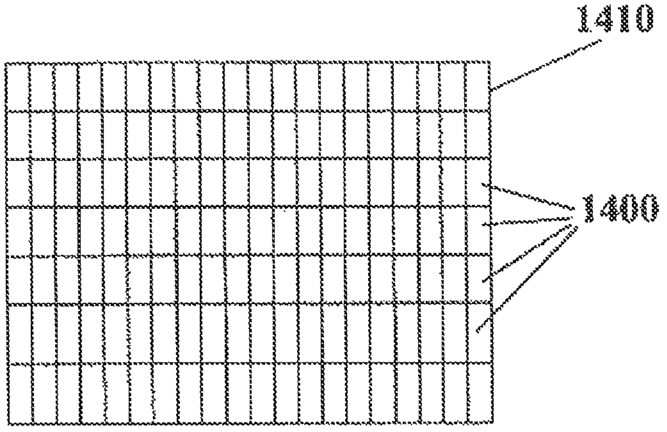

Figure 3

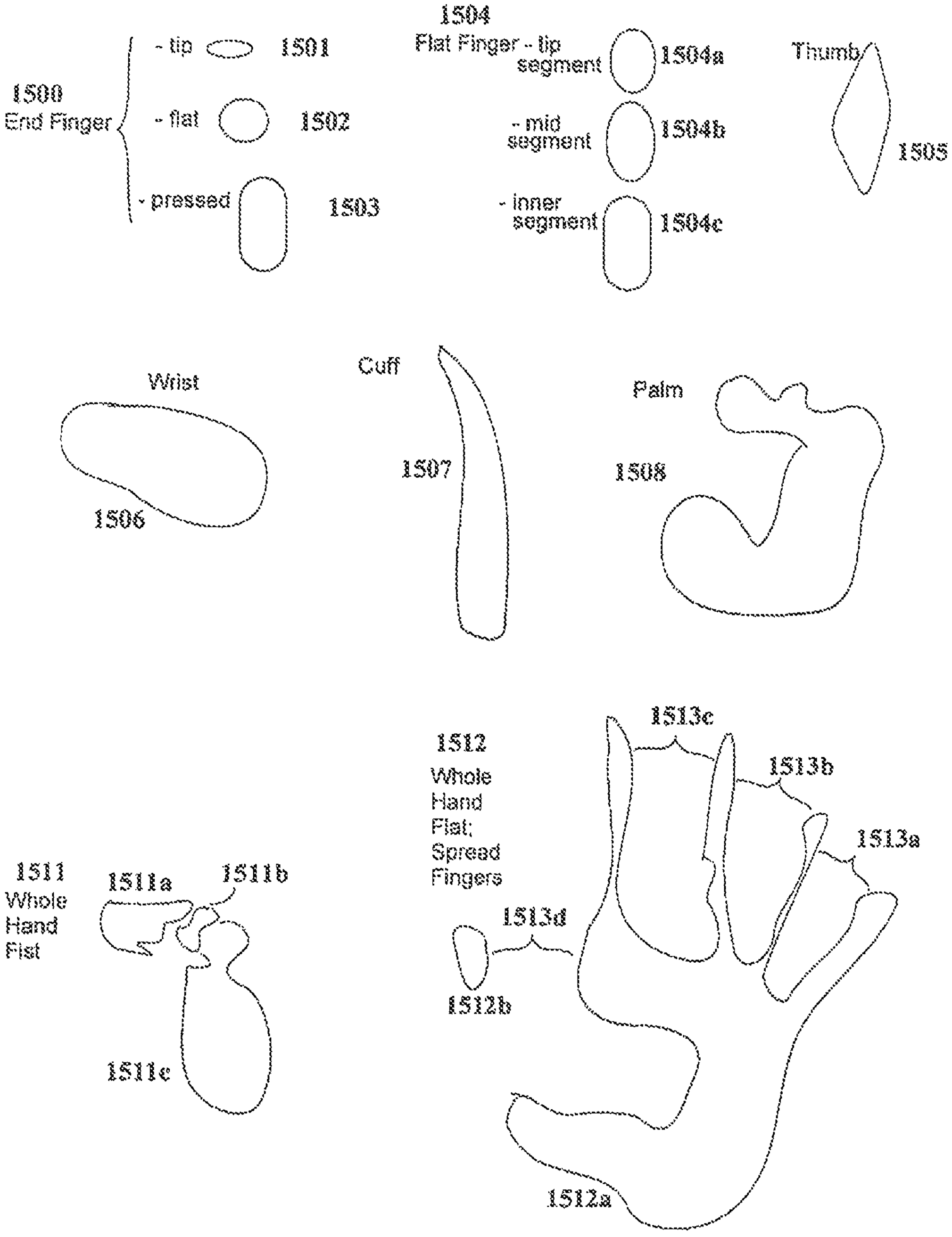
1500
End Finger
- tip
1501
- flat
1502
- pressed
1503
1504
Flat Finger - tip segment
1504a
- mid segment
1504b
- inner segment
1504c
Thumb
1505
Wrist
1506
Cuff
1507
Palm
1508
1511
Whole Hand Fist
1511a
1511b
1511c
1512
Whole Hand Flat; Spread Fingers
1513c
1513b
1513a
1513d
1512b
1512a

Figure 4

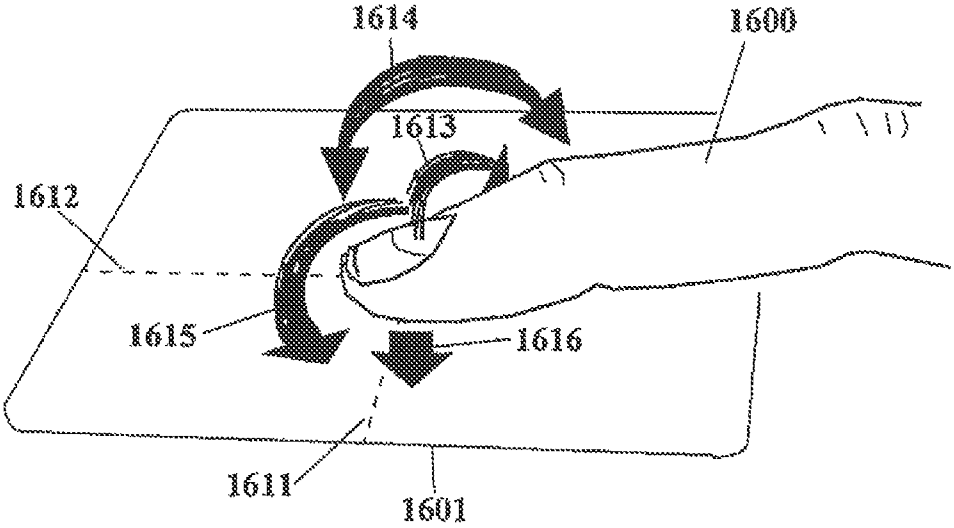

Figure 5

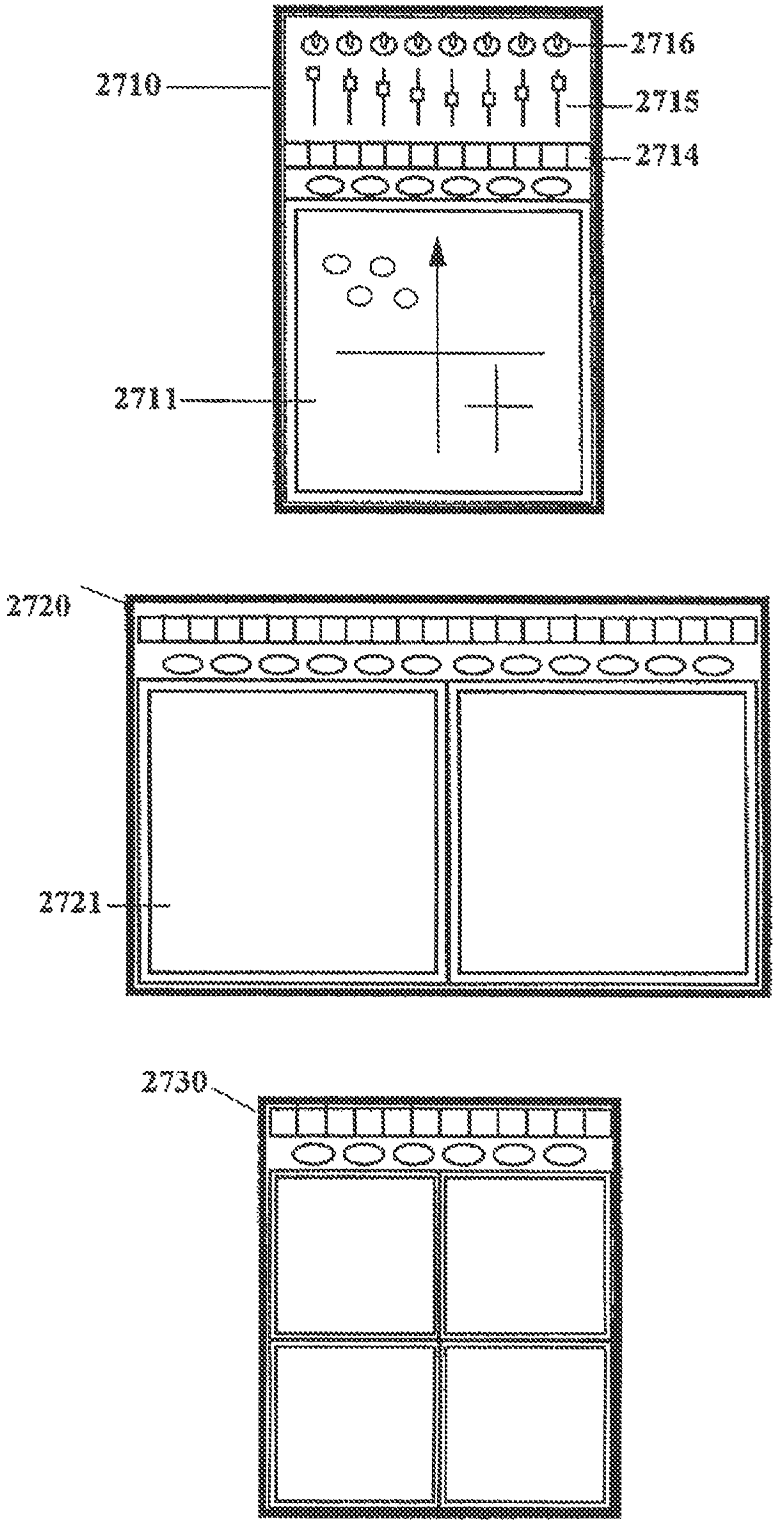

Figure 6

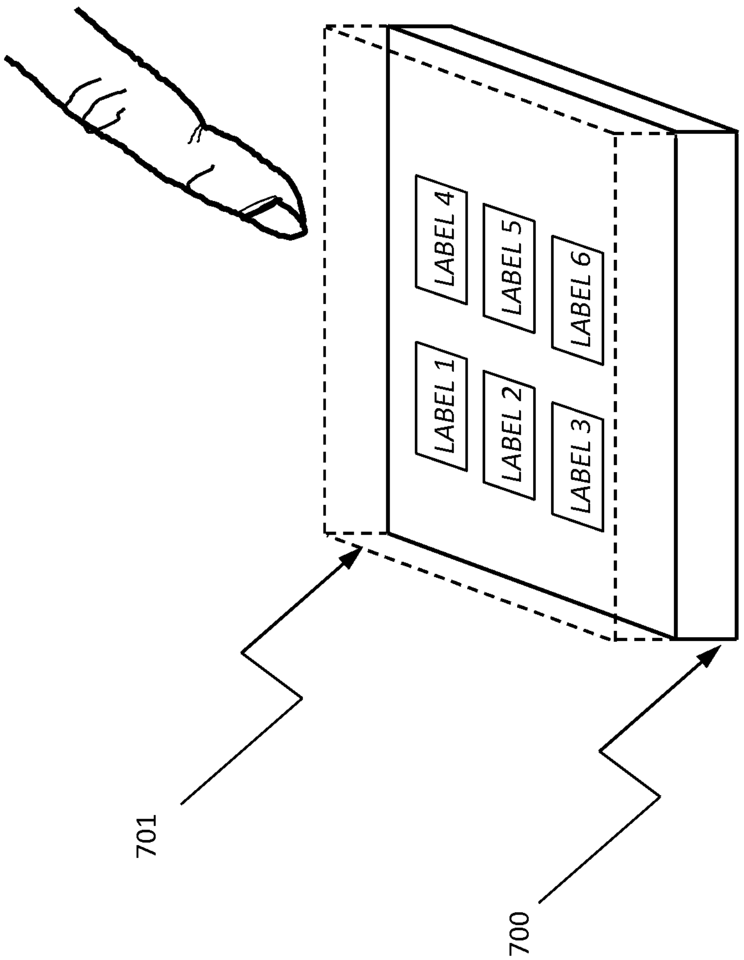

Figure 7

TOUCH SCREEN METHOD FOR RECOGNIZING A FINGER-FLICK TOUCH GESTURE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 11/761,978, filed Jun. 12, 2007, which is a continuation of U.S. application Ser. No. 09/812,400, filed Mar. 19, 2001, now U.S. Pat. No. 7,786,370, issued Aug. 31, 2010, which is a division of U.S. application Ser. No. 09/313,533, filed May 15, 1999, now U.S. Pat. No. 6,610,917, issued Aug. 26, 2003, which claims benefit of priority of U.S. provisional application Ser. No. 60/085,713, filed May 15, 1998.

FIELD OF INVENTION

The present invention relates generally to a control system, and in particular, to a touchpad user interface for controlling an associated system.

DESCRIPTION OF THE DRAWINGS

The above and other aspects, features and advantages of the present invention will become more apparent upon consideration of the following description of preferred embodiments taken in conjunction with the accompanying drawing figures, wherein:

FIG. **1** shows an example of how two independent contact points can be independently discerned, or the dimensional-width of a single contact point can be discerned, for a resistance null/contact controller with a single conductive contact plate or wire and one or more resistive elements whose resistance per unit length is a fixed constant through each resistive element;

FIG. **2** shows how a pressure-sensor array touch-pad can be combined with image processing to assign parameterized interpretations to measured pressure gradients and output those parameters as control signals;

FIG. **3** illustrates the positioning and networking of pressure sensing and processing "mini-array" chips in larger contiguous structures;

FIG. **4** illustrates the pressure profiles for a number of example hand contacts with a pressure-sensor array;

FIG. **5** illustrates how six degrees of freedom can be recovered from the contact of a single finger; and

FIG. **6** illustrates examples of single, double, and quadruple touch-pad instruments with pads of various sizes and supplemental instrument elements.

FIG. **7** illustrates an example implementation involving dynamically assigned labels.

DETAILED DESCRIPTION

Overview

Described herein are two kinds of novel touch-pads. Null/contact touchpads are contact-position sensing devices that normally are in a null state unless touched and produce a control signal when touched whose signal value corresponds to typically one unique position on the touch-pad. A first enhancement is the addition of velocity and/or pressure sensing. A second enhancement is the ability to either discern each dimensional-width of a single contact area or, alternatively, independently discern two independent contact points in certain types of null/contact controllers. A third possible enhancement is that of employing a touch-screen instance of null/contact touch pad and positioning it over a video display.

The invention also provides for a pressure-sensor array touch-pad. A pressure-sensor array touch-pad of appropriate sensitivity range, appropriate "pixel" resolution, and appropriate physical size is capable of measuring pressure gradients of many parts of the human hand or foot simultaneously. A pressure-sensor array touch-pad can be combined with image processing to assign parameterized interpretations to measured pressure gradients and output those parameters as control signals. The pressure-sensor "pixels" of a pressure-sensor array are interfaced to a data acquisition stage; the data acquisition state looks for sensor pixel pressure measurement values that exceed a low-level noise-rejection/deformity-reject threshold; contiguous regions of sufficiently high pressure values are defined; the full collection of region boundaries are subjected to classification tests; various parameters are derived from each independent region; and these parameters are assigned to the role of specific control signals which are then output to a signal routing, processing, and synthesis entity.

It is possible to derive a very large number of independent control parameters which are easily manipulated by the operating user. For example, six degrees of freedom can be recovered from the contact of a single finger. A whole hand posture can yield **17** instantaneously and simultaneously measurable parameters which are independently adjustable per hand. The recognized existence and/or derived parameters from postures and gestures may be assigned to specific outgoing control signal formats and ranges. The hand is used throughout as an example, but it is understood that the foot or even other body regions, animal regions, objects, or physical phenomena can replace the role of the hand.

It will be evident to one of ordinary skill in the art that it is advantageous to have large numbers of instantaneously and simultaneously measurable parameters which are independently adjustable. For instance, a symbol in a 2-D CAD drawing can be richly interactively selected and installed or edited in moments as opposed to tens to hundreds of seconds as is required by mouse manipulation of parameters one or two at a time and the necessary mode-changes needed to change the mouse action interpretation. As a result, said touch-pad has applications in computer workstation control, general real-time machine control, computer data entry, and computer simulation environments.

Various hardware implementations are possible. A particularly advantageous implementation would be to implement a small pressure-sensor array together with data acquisition and a small processor into a single chip package that can be laid as tiles in a larger array.

Null/Contact Touch-Pads

Distinguished from panel controls and sensors are what will be termed null/contact touch-pads. This is a class of contact-position sensing devices that normally are in a null state unless touched and produce a control signal when touched whose signal value corresponds to typically one unique position on the touch-pad. Internal position sensing mechanisms may be resistive, capacitive, optical, standing wave, etc. Examples of these devices include one-dimensional-sensing ribbon controllers found on early music synthesizers, two-dimensional-sensing pads such as the early Kawala pad and more modern mini-pads found on some lap-top computers, and two-dimensional-sensing see-through touch-screens often employed in public computer kiosks.

The null condition, when the pad is untouched, requires and/or provides the opportunity for special handling. Some example ways to handle the untouched condition include:

- sample-hold (hold values issued last time sensor was touched, as does a joystick)
- bias **1107***a*, **1107***b* (issue maximal-range value, minimal-range value, mid-range value, or other value)
- touch-detect on another channel (i.e., a separate out-of-band "gate" channel).

Additional enhancements can be added to the adaptation of null/contact touch-pad controllers as instrument elements. A first enhancement is, the addition of velocity and/or pressure sensing. This can be done via global impact and/or pressure-sensors. An extreme of this is implementation of the null/contact touch-pad controller as a pressure-sensor array; this special case and its many possibilities are described later.

A second enhancement is the ability to either discern each dimensional-width of a single contact area or, alternatively, independently discern two independent contact points in certain types of null/contact controllers. FIG. **1** shows an example of how two independent contact points can be independently discerned, or the dimensional-width of a single contact point can be discerned, for a resistance null/contact controller with a single conductive contact plate (as with the Kawala pad product) or wire (as in a some types of ribbon controller products) and one or more resistive elements **1100** whose resistance per unit length is a fixed constant through each resistive element. It is understood that a one-dimensional null/contact touch-pad typically has one such resistive element while a two-dimensional null/contact touch-pad typically has two such resistive elements that operate independently in each direction.

Referring to FIG. **1**, a constant current source **1101** can be applied to the resistive element as a whole **1102***a*-**1102***b*, developing a fixed voltage across the entire resistive element **1100**. When any portion of the resistive element is contacted by either a non-trivial contiguous width and/or multiple points of contact **1104**-**1105**, part of the resistive element is shorted out **1100***a*, thus reducing the overall width-to-end resistance of the resistance element. Because of the constant current source **1101**, the voltage developed across the entire resistive element **1102***a*-**1102***b* drops by an amount equal to the portion of the resistance that is shorted out.

The value of the voltage drop then equals a value in proportion to the distance separating the extremes of the wide and/or multiple contact points **1104**-**1105**. By subtracting **1111**, **1112**, **1113** the actual voltage across the entire resistive element from the value this voltage is normally **1110**, a control voltage proportional to distance separating the extremes of the wide and/or multiple contact points **1104**-**1105** is generated. Simultaneously, the voltage difference between that of the contact plate/wire **1103** and that of the end of the resistive element closest to an external contact point **1102***a*-**1102***b* is still proportional to the distance from said end to said external contact point. Using at most simple op-amp summing and/or differential amplifiers **1108***a*, **1108***b*, **1112**, a number of potential control voltages can be derived; for example one or more of these continuously-valued signals:

- value of distance difference between external contact points (or "width"; as described above via constant current source, nominal reference voltage, and differential amplifier **1113**)
- center of a non-trivial-width region (obtained by simple averaging, i.e., sum with gain of ½)
- value of distance difference **1109***a* between one end of the resistive element and the closest external contact point (simple differential amplifier)
- value of distance difference between the other end of the resistive element and the other external contact point (sum above voltage with "width" voltage with appropriate sign) **1109***b*.

Further, through use of simple threshold comparators, specific thresholds of shorted resistive element can be deemed to be, for example, any of a single point contact, a recognized contact region width, two points of contact, etc., producing corresponding discrete-valued control signals. The detection of a width can be treated as a contact event for a second parameter analogous to the single contact detection event described at the beginning. Some example usages of these various continuous and discrete signals are:

- existence of widths or multiple contact points may be used to trigger events or timbre changes
- degree of widths may be used to control degrees of modulation or timbre changes
- independent measurement of each external contact point from the same end of the resistive element can be used to independently control two parameters. In the simplest form, one parameter is always larger than another; in more complex implementations, the trajectories of each contact point can be tracked (using a differentiator and controlled parameter assignment switch); as long as they never simultaneously touch, either parameter can vary and be larger or smaller than the other.

It is understood that analogous approaches may be applied to other null/contact touchpad technologies such as capacitive or optical.

A third possible enhancement is that of employing a touch-screen instance of null/contact touchpad and positioning it over a video display. The video display could for example provide dynamically assigned labels, abstract spatial cues, spatial gradients, line-of-site cues for fixed or motor controlled lighting, etc., which would be valuable for use in conjunction with the adapted null/contact touch-pad controller. FIG. **7** illustrates an example implementation involving dynamically assigned labels on a video display **700** for use in conjunction with a transparent touch-screen **701**.

These various methods of adapted null/contact touch-pad elements can be used stand-alone or arranged in arrays. In addition, they can be used as a component or addendum to instruments featuring other types of instrument elements.

Pressure-Sensor Array Touch-pads

The invention provides for use of a pressure-sensor array arranged as a touch-pad together with associated image processing. As with the null/contact controller, these pressure-sensor array touch-pads may be used stand-alone or organized into an array of such pads.

It is noted that the inventor's original vision of the below described pressure-sensor array touch-pad was for applications not only in music but also for computer data entry, computer simulation environments, and real-time machine control, applications to which the below described pressure-sensor array touch-pad clearly can also apply.

A pressure-sensor array touch-pad of appropriate sensitivity range, appropriate "pixel" resolution, and appropriate physical size is capable of measuring pressure gradients of many parts of the flexibly-rich human hand or foot simultaneously. FIG. **2** shows how a pressure sensor array touch-pad can be combined with image processing to assign parameterized interpretations to measured pressure gradients and output those parameters as control signals.

The pressure-sensor "pixels" of a pressure-sensor array touch-pad **1300** are interfaced to a data acquisition stage **1301**. The interfacing method may be fully parallel but in practice may be advantageously scanned at a sufficiently high rate to give good dynamic response to rapidly changing human touch gestures. To avoid the need for a buffer amplifier for each pressure-sensor pixel, electrical design may carefully balance parasitic capacitance of the scanned array with the electrical characteristics of the sensors and the scan rates; electrical scanning frequencies can be reduced by partitioning the entire array into distinct parts that are scanned in parallel so as to increase the tolerance for address settling times and other limiting processes.

Alternatively, the pressure-sensor array **1300** may be fabricated in such a way that buffer amplifier arrays can be inexpensively attached to the sensor array **1300**, or the sensors may be such that each contains its own buffer amplifier; under these conditions, design restrictions on scanning can be relaxed and operate at higher speeds. Although the pressure sensors may be likely analog in nature, a further enhancement would be to use digital-output pressure-sensor elements or sub-arrays.

The data acquisition stage **1301** looks for sensor pixel pressure measurement values that exceed a low-level noise-rejection/deformity-rejection threshold. The sufficiently high pressure value of each such sensor pixel is noted along with the relative physical location of that pixel (known via the pixel address). This noted information may be stored "raw" for later processing and/or may be subjected to simple boundary tests and then folded into appropriate running calculations as will be described below. In general, the pressure values and addresses of sufficiently high pressure value pixels are presented to a sequence of processing functions which may be performed on the noted information:

- contiguous regions of sufficiently high pressure values are defined (a number of simple run-time adjacency tests can be used; many are known—see for example [Ronse; Viberg; Shaperio; Hara])
- the full collection of region boundaries are subjected to classification tests; in cases a given contiguous region may be split into a plurality of tangent or co-bordered independently recognized regions
- various parameters are derived from each independent region, for example geometric center, center of pressure, average pressure, total size, angle-of-rotation-from reference for non-round regions, second-order and higher-order geometric moments, second-order and higher-order pressure moments, etc.
- assignment of these parameters to the role of specific control signals (note events, control parameters, etc.) which are then output to a signal routing, processing, and synthesis entity; for example, this may be done in the form of MIDI messages.

Because of the number of processes involved in such a pipeline, it is advantageous to follow a data acquisition stage **1301** with one or more additional processing stages **1303**, **1305**, **1309**, and **1311**. Of the four example processing functions just listed, the first three fall in the character of image processing. It is also possible to do a considerable amount of the image processing steps actually within the data acquisition step, namely any of simple adjacency tests and folding selected address and pressure measurement information into running sums or other running pre-calculations later used to derive aforementioned parameters. The latter method can be greatly advantageous as it can significantly collapses the amount of data to be stored.

Regardless of whether portions of the image processing are done within or beyond the data acquisition stage, there are various hardware implementations possible. One hardware approach would involve very simple front-end scanned data acquisition hardware and a single high-throughput microprocessor/signal-processor chip. Alternatively, an expanded data acquisition stage may be implemented in high-performance dedicated function hardware and this would be connected to a lower performance processor chip. A third, particularly advantageous implementation would be to implement a small pressure-sensor array together with data acquisition and a small processor into a single low-profile chip package that can be laid as tiles in a nearly seamless larger array. In such an implementation all image processing could in fact be done via straightforward partitions into message-passing distributed algorithms.

One or more individual chips could direct output parameter streams to an output processor which would organize and/or assign parameters to output control channels, perhaps in a programmable manner under selectable stored program control. A tiled macro array of such "sensor mini-array" chips could be networked by a tapped passive bus, one- or two-dimensional mode active bus daisy-chain, a potentially expandable star-wired centralized message passing chip or subsystem, or other means.

Creating a large surface from such "tile chips" will aid in the serviceability of the surface. Since these chips can be used as tiles to build a variety of shapes, it is therefore possible to leverage a significant manufacturing economy-of-scale so as to minimize cost and justify more extensive feature development. Advanced seating and connector technologies, as used in laptops and other high-performance miniature consumer electronics, can be used to minimize the separation between adjacent chip "tiles" and resultant irregularities in the tiled-surface smoothness. A tiled implementation may also include a thin rugged flexible protective film that separates the sensor chips from the outside world. FIG. **3** illustrates the positioning and networking of pressure sensing and processing "mini-array" chips **1400** in larger contiguous structures **1410**.

With the perfection of a translucent pressure-sensor array, it further becomes possible for translucent pressure-sensor arrays to be laid atop aligned visual displays such as LCDs, florescent, plasma, CRTs, etc. as was discussed above for null/contact touch-pads. The displays can be used to label areas of the sensor array, illustrate gradients, etc. FIG. **7** illustrates an example implementation involving dynamically assigned labels on a video display **700** for use in conjunction with a transparent touch-screen **701**. Note that in the "tile chip" implementation, monochrome or color display areas may indeed be built into each chip.

Returning now to the concept of a pressure-sensor array touch-pad large enough for hand-operation: examples of hand contact that may be recognized, example methods for how these may be translated into control parameters, and examples of how these all may be used are now described. In the below the hand is used throughout as an example, but it is understood that the foot or even other body regions, animal regions, objects, or physical phenomena can replace the role of the hand in these illustrative examples.

FIG. **4** illustrates the pressure profiles for a number of example hand contacts with a pressure-sensor array. In the case **1500** of a finger's end, pressure on the touch-pad pressure-sensor array can be limited to the finger tip, resulting in a spatial pressure distribution profile **1501**; this shape does not change much as a function of pressure. Alternatively, the finger can contact the pad with its flat region, resulting in light pressure profiles **1502** which are smaller in size than heavier pressure profiles **1503**. In the case **1504** where the entire finger touches the pad, a three-segment pattern (**1504***a*, **1504***b*, **1504***c*) will result under many conditions; under light pressure a two segment pattern (**1504***b* or **1504***c* missing) could result. In all but the lightest pressures the thumb makes a somewhat discernible shape **1505** as do the wrist **1506**, cuff **1507**, and palm **1508**; at light pressures these patterns thin and can also break into disconnected regions. Whole hand patterns such as the fist **1511** and flat hand **1512** have more complex shapes. In the case of the fist **1511**, a degree of curl can be discerned from the relative geometry and separation of sub-regions (here depicted, as an example, as **1511***a*, **1511***b*, and **1511***c*). In the case of the whole flat hand **1512**, there can be two or more sub-regions which may be in fact joined (as within **1512***a*) and/or disconnected (as an example, as **1512***a* and **1512***b* are); the whole hand also affords individual measurement of separation "angles" among the digits and thumb (**1513***a*, **1513***b*, **1513***c*, **1513***d*) which can easily be varied by the user.

Relatively simple pattern recognition software can be used to discern these and other hand contact patterns which will be termed "postures." The pattern recognition working together with simple image processing may, further, derive a very large number of independent control parameters which are easily manipulated by the operating user. In many cases it may be advantageous to train a system to the particulars of a specific person's hand(s) and/or specific postures. In other situations the system may be designed to be fully adaptive and adjust to a person's hand automatically. In practice, for the widest range of control and accuracy, both training and ongoing adaptation may be useful. Further, the recognized postures described thus far may be combined in sequence with specific dynamic variations among them (such as a finger flick, double-tap, etc.) and as such may be also recognized and thus treated as an additional type of recognized pattern; such sequential dynamics among postures will be termed "gestures."

The admission of gestures further allows for the derivation of additional patterns such as the degree or rate of variation within one or more of the gesture dynamics. Finally, the recognized existence and/or derived parameters from postures and gestures may be assigned to specific outgoing control signal formats and ranges. Any training information and/or control signal assignment information may be stored and recalled for one or more players via stored program control.

For each recognized pattern, the amount of information that can be derived as parameters is in general very high. For the human hand or foot, there are, typically, artifacts such as shape variation due to elastic tissue deformation that permit recovery of up to all six degrees of freedom allowed in an object's orientation in 3-space.

FIG. **5** illustrates how six degrees of freedom can be recovered from the contact of a single finger. In the drawing, the finger **1600** makes contact with the touch-pad **1601** with its end segment at a point on the touch-pad surface determined by coordinates **1611** and **1612** (these would be, for example, left/right for **1611** and forward/backward for **1612**). Fixing this point of contact, the finger **1600** is also capable of rotational twisting along its length **1613** as well as rocking back and forth **1614**. The entire finger can also be pivoted with motion **1615** about the contact point defined by coordinates **1611** and **1612**. These are all clearly independently controlled actions, and yet it is still possible in any configuration of these thus far five degrees of freedom, to vary the overall pressure **1616** applied to the contact point. Simple practice, if it is even needed, allows the latter overall pressure **1616** to be independently fixed or varied by the human operator as other parameters are adjusted.

In general other and more complex hand contacts, such as use of two fingers, the whole hand, etc. forfeit some of these example degrees of freedom but often introduce others. For example, in the quite constrained case of a whole hand posture, the fingers and thumb can exert pressure independently (5 parameters), the finger and thumb separation angles can be varied (4 parameters), the finger ends **1504***a* can exert pressure independently from the middle **1504***b* and inner **1504***c* segments (4 parameters), the palm can independently vary its applied pressure (1 parameter) while independently tilting/rocking in two directions (2 parameters) and the thumb can curl (1 parameter), yielding 17 instantaneously and simultaneously measurable parameters which are independently adjustable per hand. Complex contact postures may also be viewed as, or decomposed into, component sub-postures (for example here, as flat-finger contact, palm contact, and thumb contact) which would then derive parameters from each posture independently. For such complex contact postures, recognition as a larger compound posture which may then be decomposed allows for the opportunity to decouple and/or renormalize the parameter extraction in recognition of the special affairs associated with and constraints imposed by specific complex contact postures.

It is noted that the derived parameters may be pre-processed for specific uses. One example of this would be the quantization of a parameter into two or more discrete steps; these could for example be sequentially interpreted as sequential notes of a scale or melody. Another example would be that of warping a parameter range as measured to one with a more musically expressive layout.

Next examples of the rich metaphorical aspects of interacting with the pressure sensor array touch-pad are illustrated. In many cases there may be one or more natural geometric metaphor(s) applicable, such as associating left-right position, left-right twisting, or left-right rotation with stereo panning, or in associating overall pressure with volume or spectral complexity. In more abstract cases, there may be pairs of parameters that go together—here, for example with a finger end, it may be natural to associate one parameter pair with (left/right and forward/backward) contact position and another parameter pair with (left/right and forward/backward) twisting/rocking. In this latter example there is available potential added structure in the metaphor by viewing the twisting/rocking plane as being superimposed over the position plane. The superposition aspect of the metaphor can be viewed as an index, or as an input-plane/output-plane distinction for a two-input/two-output transformation, or as two separated processes which may be caused to converge or morph according to additional overall pressure, or in conjunction with a dihedral angle of intersection between two independent processes, etc.

Next, examples of the rich syntactical aspects of interacting with the pressure-sensor array touch-pad are illustrated. Some instruments have particular hand postures naturally associated with their playing. It is natural then to recognize these classical hand-contact postures and derive control parameters that match and/or transcend how a classical player would use these hand positions to evoke and control sound from the instrument. Further, some postures could be recognized either in isolation or in gestural-context as being ones associated with (or assigned to) percussion effects while remaining postures may be associated with accompanying melodies or sound textures.

As an additional syntactic aspect, specific hand postures and/or gestures may be mapped to specific selected assignments of control signals in ways affiliated with specific purposes. For example, finger ends may be used for one collection of sound synthesis parameters, thumb for a second potentially partially overlapping collection of sound synthesis parameters, flat fingers for a third partially-overlapping collection, wrist for a fourth, and cuff for a fifth, and first for a sixth. In this case it may be natural to move the hand through certain connected sequences of motions; for example: little finger end, still in contact, dropping to flat-finger contact, then dropping to either palm directly or first to cuff and then to palm, then moving to wrist, all never breaking contact with the touch-pad. Such permissible sequences of postures that can be executed sequentially without breaking contact with the touch-pad will be termed "continuous grammars."

Under these circumstances it is useful to set up parameter assignments, and potentially associated context-sensitive parameter renormalizations, that work in the context of selected (or all available) continuous grammars. For example, as the hand contact evolves as being recognized as one posture and then another, parameters may be smoothly handed-over in interpretation from one posture to another without abrupt changes, while abandoned parameters either hold their last value or return to a default value (instantly or via a controlled envelope).

Now a number of example applications of the pressure-sensor array touchpad are provided. It is known to be possible and valuable to use the aforementioned pressure-sensor array touch-pad, implicitly containing its associated data acquisition, processing, and assignment elements, for many, many applications such as general machine control and computer workstation control. One example of machine control is in robotics: here a finger might be used to control a hazardous material robot hand as follows:

left/right position: left/right hand position
in/out position: in/out hand position
in/out rock: up/down hand position
rotation: hand grip approach angle
overall pressure: grip strength
left/right twist: gesture to lock or release current grip from pressure control

A computer workstation example may involve a graphical Computer-Aided Design application currently requiring intensive mouse manipulation of parameters one or two at a time:

left/right position: left/right position of a selected symbol in a 2-D CAD drawing
in/out position: up/down position of a selected symbol in 2-D CAD drawing
left/right twist: symbol selection—left/right motion through 2-D palette
in/out rock: symbol selection—up/down motion through 2-D palette
rotation: rotation of selected symbol in the drawing
overall pressure: sizing by steps
tap of additional finger: lock selection into drawing or unlock for changes
tap of thumb: undo
palm: toggle between add new object and select existing object

Clearly a symbol can be richly interactively selected and installed or edited in moments as opposed to tens to hundreds of seconds as is required by mouse manipulation of parameters one or two at a time and the necessary mode-changes needed to change the mouse action interpretation.

Touch-Pad Array

Touch-pad instrument elements, such as null/contact types and pressure-sensor array types described earlier, can be used in isolation or arrays to create electronic controller instruments. The touch-pad(s) may be advantageously supplemented with panel controls such as push buttons, sliders, knobs as well as impact sensors for velocity-controlled triggering of percussion or pitched note events. If one or more of the touch-pads is transparent (as in the case of a null/contact touch screen overlay) one or more video, graphics, or alphanumeric displays **2711** may placed under a given pad or group of pads.

FIG. **6** illustrates examples of single **2710**, double **2720**, and quadruple **2730** touchpad instruments with pads of various sizes. A single touch-pad could serve as the central element of such an instrument, potentially supplemented with panel controls such as push buttons **2714**, sliders **2715**, knobs **2716** as well as impact sensors. In FIG. **6**, a transparent pad superimposed over a video, graphics, or one or more alphanumeric displays is assumed, and specifically shown is a case of underlay graphics cues being displayed for the player. Two large sensors can be put side by side to serves as a general purpose left-hand/right-hand multi-parameter controller.

All publications and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference. The invention now being fully described, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from its spirit or scope.

REFERENCES CITED

The following references are cited in this patent application using the format of the first one or two authors last name(s) within square brackets"[ ]", multiple references within a pair of square brackets separated by semicolons ";"

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[Viberg] Viberg, Mats, *Subspace Fitting Concepts in Sensor Array Processing*, Linkoping Studies in Science and Technology. Dissertations No. 27 Linkoping, Sweden 1989;

[Shapiro] Shapiro, Larry S, *Affine Analysis of Image Sequences*, Cambridge University Press, 1995;

[Hara] Hara, Yoshiko "Matsushita demos multilayer MPEG-4 compression", Electronic Engineering Times, Apr. 19, 1999.

I claim:

1. A computer-implemented method of implementing a touch screen of an electronic device, the method comprising:

facilitating communication between a processor and a plurality of transparent sensors overlaid on top of a visual display that is associated with the electronic device to form the touch screen, each transparent sensor configured to be responsive to touch by at least one user finger, and the visual display for rendering visual information provided by the electronic device;

associating control parameters with sensor measurements sensed by the plurality of transparent sensors; and

assigning the control parameters to specific control signals to allow user interaction with the electronic device by touching the touch screen, the touching producing the sensor measurements by the plurality of transparent sensors;

wherein the control parameters include parameters derived from recognizing a finger-flick touch gesture, the finger-flick touch gesture recognized from a sequence of postures with specific dynamic variations among them, the sequence of postures being recognized from pressure profiles.

2. The computer-implemented method of claim **1**, further comprising:

recognizing a plurality of patterns of touch; and

deriving control parameters from the recognized plurality of patterns of touch.

3. The computer-implemented method of claim **2**, wherein the recognizing the plurality of patterns of touch comprises recognizing the touching of the touch screen by a single finger positionable with at least four degrees of freedom with respect to the touch screen, and recognizing each of the at least four degrees of freedom of the single finger with respect to the touch screen.

4. The computer-implemented method of claim **1** wherein the recognizing the at least one gesture comprises recognizing a contact with one finger and tap of an additional finger.

5. The computer-implemented method of claim **1** wherein the recognizing the at least one gesture comprises recognizing simultaneous movement of two fingers.

6. The computer-implemented method of claim **1**, wherein the recognizing the plurality of patterns of touch comprises recognizing the touching of the touch screen by a single finger positionable with at least five degrees of freedom with respect to the touch screen, and recognizing each of the at least five degrees of freedom of the single finger with respect to the touch screen.

7. The computer-implemented method of claim **1**, wherein the recognizing the plurality of patterns of touch comprises recognizing the touching of the touch screen by a single finger positionable with at least six degrees of freedom with respect to the touch screen, and recognizing each of the at least six degrees of freedom of the single finger with respect to the touch screen.

8. The computer-implemented method of claim **1**, further comprising defining at least one contiguous region comprising associated pixel addresses based on values of the sensor measurements that exceed a threshold value.

9. The computer-implemented method of claim **8**, further comprising classifying the at least one defined contiguous region based on values of the sensor measurements that exceed the threshold value.

10. The computer-implemented method of claim **8** wherein the control parameters are derived based on the at least one defined contiguous region.

11. The computer-implemented method of claim **1** further comprising defining a plurality of contiguous regions comprising associated pixel addresses: and

deriving the control parameters for each of the plurality of contiguous regions having sensed measurements with values that exceed a threshold value.

12. The computer-implemented method of claim **1**, further comprising controlling a software application running on the electronic device based on the touching.

13. The computer-implemented method of claim **1**, further comprising controlling an operation of the electronic device based on the touching.

14. The computer-implemented method of claim **1**, further comprising adjusting the operation for at least one particular user hand.

15. The computer-implemented method of claim **1**, wherein the visual display is an LCD display.

16. The computer-implemented method of claim **1**, wherein the sensor measurements comprise spatial location of the user finger from values of the plurality of transparent sensors exceeding a threshold value,

and

wherein at least one control parameter comprises a rate of variation in spatial location of the finger, the rate of variation derived from the sensor measurements sensed by the plurality of transparent sensors.

17. The computer-implemented method of claim **1**, wherein the sequence of postures is recognized from the pressure profiles using pattern recognition.

18. The computer-implemented method of claim **1**, wherein the pressure profiles comprise pressure profiles of the user's finger on the touch screen.

19. A computer-implemented method of implementing a touch screen of an electronic device, the method comprising:

facilitating communication between a processor and a plurality of transparent sensors overlaid on top of a visual display that is associated with the electronic device to form the touch screen, each transparent sensor configured to be responsive to touch by at least one user finger, and the visual display for rendering visual information provided by the electronic device;

associating control parameters with sensor measurements sensed by the plurality of transparent sensors, wherein the control parameters include parameters derived from recognizing a finger-flick touch gesture, the finger-flick touch gesture recognized from a sequence of postures with specific dynamic variations among them, the sequence of postures being recognized from pressure profiles.

20. The computer-implemented method of claim **19**, wherein the sensor measurements comprise spatial location of the user finger from values of the plurality of transparent sensors exceeding a threshold value, and

wherein at least one control parameter comprises a rate of variation in spatial location of the finger based on the sensor measurements sensed by the plurality of transparent sensors.

21. The computer-implemented method of claim **19**, wherein the sequence of postures is recognized from the pressure profiles using pattern recognition.

22. The computer-implemented method of claim **19**, wherein the pressure profiles comprise pressure profiles of the user's finger on the touch screen.

23. A computer-implemented method of implementing a touch screen of an electronic device, the method comprising:

facilitating communication between a processor and a plurality of transparent sensors overlaid on top of a visual display that is associated with the electronic device to form the touch screen, each transparent sensor configured to be responsive to touch by at least one user finger, and the visual display for rendering visual information provided by the electronic device;

deriving control parameters from sensor measurements sensed by the plurality of transparent sensors;

providing one or more dynamically assigned labels for display by the visual display to label one or more areas of the plurality of transparent sensors;

assigning the control parameters to specific control signals to allow user interaction with the electronic device by touching the touch screen over the labeled one or more areas of the plurality of transparent sensors indicated by the one or more dynamically assigned labels comprising at least one graphical underlay that is displayed by the visual display, the touching producing the sensor measurements by the plurality of transparent sensors; and

wherein the sensor measurements comprise spatial location of the user finger from values of the plurality of transparent sensors exceeding a threshold value,

wherein at least one control parameter is derived from recognizing a finger-flick touch gesture, the finger-flick touch gesture recognized from a sequence of postures with specific dynamic variations among them, the sequence of postures being recognized from pressure profiles, and

wherein at least one control parameter comprises a rate of variation in spatial location of the finger as moved in the dynamics of the gesture, the rate of variation derived from the sensor measurements sensed by the plurality of transparent sensors.

24. The computer-implemented method of claim **23**, wherein the sequence of postures is recognized from the pressure profiles using pattern recognition.

25. The computer-implemented method of claim **23**, wherein the pressure profiles comprise pressure profiles of the user's finger on the touch screen.

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