FORCE IMAGING INPUT DEVICE AND SYSTEM

BACKGROUND

[0001] The invention relates generally to electronic system input devices and, more particularly, to force imaging and location-and-force imaging mutual capacitance systems.

[0002] Numerous touch sensing devices are available for use in computer systems, personal digital assistants, mobile phones, game systems, music systems and the like (i.e., electronic systems). Perhaps the best known are resistive-membrane position sensors which have been used as keyboards and position indicators for a number of years. Other types of touch sensing devices include resistive tablets, surface acoustic wave devices, touch sensors based on resistance, capacitance, strain gages, electromagnetic sensors or pressure sensors, and optical sensors. Pressure sensitive position sensors have historically offered little benefit for use as a pointing device (as opposed to a data entry or writing device) because the pressure needed to make them operate inherently creates stiction between the finger and the sensor surface. Such stiction has, in large measure, prevented such devices from becoming popular.

[0003] Owing to the growing popularity of portable devices and the attendant need to integrate all input functions into a single form factor, the touch pad is now one of the most popular and widely used types of input device. Operationally, touch pads may be categorized as either "resistive" or "capacitive." In resistive touch pads, the pad is coated with a thin metallic electrically conductive layer and resistive layer. When the pad is touched, the conductive layers come into contact through the resistive layer causing a change in resistance (typically measured as a change in current) that is used to identify where on the pad the touch event occurred. In capacitive touch pads, a first set of conductive traces run in a first direction and are insulated by a dielectric insulator from a second set of conductive traces running in a second direction (generally orthogonal to the first direction). The grid formed by the overlapping conductive traces create an array of capacitors that can store electrical charge. When an object is brought into proximity or contact with the touch pad, the capacitance of the capacitors at that location change. This change can be used to identify the location of the touch event.

[0004] One drawback to using touch pads as input devices is that they do not generally provide pressure or force information. Force information may be used to obtain a more robust indication of how a user is manipulating a device. That is, force information may be used as another input dimension for purposes of providing command and control signals to an associated electronic device. Thus, it would be beneficial to provide a force measurement system as part of a touch pad input device.

SUMMARY

[0005] In one embodiment the invention provides a force sensitive touch pad that includes first and second sets of conductive traces separated by a spring membrane. When a force is applied, the spring membrane deforms moving the two sets of traces closer together. The resulting change in mutual capacitance is used to generate an image indicative of the location (relative to the surface of the touch pad) and strength or intensity of an applied force. In another embodiment, the invention provides a combined location and force sensitive touch pad that includes two sets of drive traces, one set of sense traces and a spring membrane. In operation, one of the drive traces is used in combination with the set of sense traces to generate an image of where one or more objects touch the touch pad. The second set of drive traces is used in combination with the sense traces and spring membrane to generate an image of the applied force's strength or intensity and its location relative to the touch pad's surface. Force touch pads and location and force touch pads in accordance with the invention may be incorporated in a variety of electronic devices to facilitate recognition of an increased array of user manipulation.

[0006] In yet another embodiment, the described force sensing architectures may be used to implement a display capable of detecting the amount of force a user applies to a display (e.g., a liquid crystal display unit). Display units in accordance with this embodiment of the invention may be used to facilitate recognition of an increased array of user input.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** shows, in exploded perspective view, a force detector in accordance with one embodiment of the invention.

[0008] FIGS. **2**A and **2**B show, in cross-section, an unloaded (A) and loaded (B) force detector in accordance with FIG. **1**.

[0009] FIG. **3** shows, in block diagram form, a force detection system in accordance with one embodiment of the invention.

[0010] FIG. **4** shows, in block diagram form, a more detailed view of the force detection system in accordance with FIG. **3**.

[0011] FIG. **5** shows, in cross-section, a location and force detection device in accordance with one embodiment of the invention.

[0012] FIG. **6** shows, in cross section, a location and force detection device in accordance with another embodiment of the invention.

[0013] FIG. **7** shows an exploded view of drive and sense traces in accordance with FIG. **6**.

[0014] FIGS. **8**A-**8**C show various views of a location and force detection device in accordance with still another embodiment of the invention.

[0015] FIGS. **9**A-**9**C show various views of a location and force detection device in accordance with yet another embodiment of the invention.

[0016] FIGS. **10**A and **10**B show, in cross section, a location and force detection device in accordance with another embodiment of the invention.

[0017] FIGS. **11**A-**11**C show various views of a spring membrane in accordance with another embodiment of the invention.

[0018] FIGS. **12**A and **12**B show, in block diagram form, a force detection display system in accordance with one embodiment of the invention.