METHOD AND APPARATUS FOR FORCE-BASED TOUCH INPUT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is related to concurrently filed and commonly owned patent application entitled "Tangential Force Control in a Touch Location Device," hereby incorporated by reference in its entirety.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to touch sensors and, more particularly, to force sensing touch location devices.

[0004] 2. Related Art

[0005] The ability to sense and measure the force and/or location of a touch applied to a surface is useful in a variety of contexts. As a result, various systems have been developed in which force sensors are used to measure properties of a force (referred to herein as a "touch force") applied to a surface (referred to herein as a "touch surface"). Force sensors typically generate signals in response to the touch force that may be used, for example, to locate the position on the touch surface at which the touch force is applied. A number of particular implementations of this approach have been proposed, such as that described by Peronneau et al. in U.S. Pat. No. 3,657,475.

[0006] Such touch location is of particular interest when the touch surface is that of a computer display, or that of a transparent overlay in front of a computer display. Furthermore the need for small, lightweight, and inexpensive devices that are capable of performing touch location is increasing due to the proliferation of mobile and handheld devices, such as personal digital assistants (PDAs). The touch screens which perform this function may be built with a number of possible technologies. In addition to the force principle just mentioned, capacitive, resistive, acoustic, and infrared techniques are among those that have been used.

[0007] The force principle has some strong potential advantages over these competing techniques. Since force techniques may be applied to any overlay material, or indeed to the entire display itself, there is no need to interpose materials or coatings with low durability or poor optical properties. Also, since force is the basis of perceived touch, there is no problem with sensitivity seeming unpredictable to the user. With capacitive measurement, for instance, touch threshold varies with the condition of the user's skin, and with interposed materials, such as a glove. Stylus contact typically gives no response. With resistive measurement, threshold force depends upon the size of the contact area, and so is very different between stylus and finger. Acoustic measurement depends upon the absorptive characteristics of the touching material; and with infrared, a touch may register when there has been no contact.

[0008] In spite of these advantages of force-based technologies, resistive and capacitive technologies have dominated in the touch screen market. This reflects residual difficulties with known force techniques, which must be overcome to realize the potential of force technology.

[0009] Among these difficulties are:

[0010] Excessive force sensor size—especially width and thickness.

[0011] Excessive sensitivity to transverse forces, leading to inaccuracy.

[0012] Excessive force sensor cost and complexity.

[0013] Excessive sensitivity to deformations of the touch surface or its supporting structure, leading to inaccuracy.

[0014] The need to keep the touch surface mechanically independent of the application bezel that encloses the touch surface, which makes it difficult to integrate the touch screen into the larger structure, and makes it difficult to provide a good liquid and dust seal.

[0015] In modern touch applications, it is extremely important that provisions for touch force location and/or measurement not increase the size nor dictate the appearance of the touch-equipped device. This is especially true in portable and handheld applications. Conventional force sensors of the type required are typically much thicker than resistive or capacitive films, thereby potentially increasing the thickness of devices that incorporate such force sensors compared to devices that incorporate resistive or capacitive sensors. Since conventional force sensors of the type required cannot easily be made transparent, they cannot be placed in front of an active display area. As a result, devices including such conventional force sensors must typically be made wider than a resistive- or capacitive-based device to accommodate the force sensors. Thus force-based touch is potentially disadvantageous with respect both to overall device thickness and width, when compared to other kinds of conventional touch sensors.

[0016] Thus it is seen that the prior art fails to teach how force sensors may be made sufficiently narrow, thin, and inexpensive.

[0017] A touch force applied to a touch surface has both a component that is normal to the touch plane (the "perpendicular component") and a component that is parallel to the touch plane (the "tangential component"). The presence of a tangential component can introduce errors in the computed touch location. Various techniques for reducing the errors introduced by tangential forces are described in more detail in the co-pending application entitled "Tangential Force Control in a Touch Location Device."

[0018] In many applications it may be desirable for an application bezel to press firmly around the edges of a touch-equipped display or display overlay module. This arrangement provides a dust and/or liquid seal, and may also serve to stiffen and align the bezel. With force-sensing touch-location devices, however, the bezel does not typically rest directly against a force sensitive structure, since the variable handling forces thereby transmitted would interfere excessively with touch location accuracy. The prior art does not teach satisfactory methods for sealing, nor for sufficiently diverting bezel forces in force-based based touch systems.

SUMMARY

[0019] In one of its aspects, the invention provides a novel capacitive force sensor. The sensor comprises a principal