Thus it would be an advance in the art to provide a motion continuation method which does not become activated unexpectedly when the user really intended to stop pointer movement at a target but happens to be on a border or happens to be moving at significant speed during liftoff.

Many attempts have been made to embed pointing devices in a keyboard so the hands do not have to leave typing position to access the pointing device. These include the integrated pointing key described in U.S. Pat. No. 5,189,403 to Franz et al., the integrated pointing stick disclosed by J. Rutledge and T. Selker in "Force-to-Motion Functions for Pointing," Human-Computer Interaction—INTERACT '90, pp. 701-06 (1990), and the position sensing keys described in U.S. Pat. No. 5,675,361 to Santilli. Nevertheless, the limited movement range and resolution of these devices, leads to poorer pointing speed and accuracy than a mouse, and they add mechanical complexity to keyboard construction. Thus there exists a need in the art for pointing methods with higher resolution, larger movement range, and more degrees of freedom yet which are easily accessible from typing hand positions.

Touch screens and touchpads often distinguish pointing motions from emulated button clicks or keypresses by assuming very little lateral fingertip motion will occur during taps on the touch surface which are intended as clicks. Inherent in these methods is the assumption that tapping will usually be straight down from the suspended finger position, minimizing those components of finger motion tangential to the surface. This is a valid assumption if the surface is not finely divided into distinct key areas or if the user does a slow, "hunt and peck" visual search for each key before striking. For example, in U.S. Pat. No. 5,543,591 to Gillespie et al., a touchpad sends all lateral motions to the host computer as cursor movements. However, if the finger is lifted soon enough after touchdown to count as a tap and if the accumulated lateral motions are not excessive, any sent motions are undone and a mouse button click is sent instead. This method only works for mouse commands such as pointing which can safely be undone, not for dragging or other manipulations. In U.S. Pat. No. 5,666,113 to Logan, taps with less than about 1/16" lateral motion activate keys on a small keypad while lateral motion in excess of 1/16" activates cursor control mode. In both patents cursor mode is invoked by default when a finger stays on the surface a long time.

However, fast touch typing on a surface divided into a large array of key regions tends to produce more tangential motions along the surface than related art filtering techniques can tolerate. Such an array contains keys in multiple rows and columns which may not be directly under the fingers, so the user must reach with the hand or flex or extend fingers to touch many of the key regions. Quick reaching and extending imparts significant lateral finger motion while the finger is in the air which may still be present when the finger contacts the surface. Glancing taps with as much as 1/4") lateral motion measured at the surface can easily result. Attempting to filter or suppress this much motion would make the cursor seem sluggish and unresponsive. Furthermore, it may be desirable to enter a typematic or automatic key repeat mode instead of pointing mode when the finger is held in one place on the surface. Any lateral shifting by the fingertip during a prolonged finger press would also be picked up as cursor jitter without heavy filtering. Thus, there is a need in the art for a method to distinguish keying from pointing on the same surface via more robust hand configuration cues than lateral motion of a single finger.

An ergonomic typing system should require minimal key tapping force, easily distinguish finger taps from resting hands, and cushion the fingers from the jarring force of surface impact. Mechanical and membrane keyboards rely on the spring force in the keyswitches to prevent activation when the hands are resting on the keys. This causes an irreconcilable tradeoff between the ergonomic desires to reduce the fatigue from key activating force and to relax the full weight of the hands onto the keys during rest periods. Force minimization on touch surfaces is possible with capacitive or active optical sensing, which do not rely on finger pressure, rather than resistive-membrane or surface-acoustic-wave sensing techniques. The related art touch devices discussed below will become confused if a whole hand including its four fingertips a thumb and possibly palm heels, rests on the surface. Thus, there exists a long felt need in the art for a multi-touch surface typing system based on zero-force capacitive sensing which can tolerate resting hands and a surface cushion.

An ergonomic typing system should also adapt to individual hand sizes tolerate variations in typing style, and support a range of healthy hand postures. Though many ergonomic keyboards have been proposed, mechanical keyswitches can only be repositioned at great cost. For example, the keyboard with concave keywells described by Hargreaves et al. in U.S. Pat. No. 5,689,253 fits most hands well but also tends to lock the arms in a single position. A touch surface key layout could easily be morphed, translated, or arbitrarily reconfigured as long as the changes did not confuse the user. However, touch surfaces may not provide as much laterally orienting tactile feedback as the edges of mechanical keyswitches. Thus, there exists a need in the art for a surface typing recognizer which can adapt a key layout to fit individual hand postures and which can sustain typing accuracy if the hands drift due to limited tactile feedback.

Handwriting on smooth touch surfaces using a stylus is well-known in the art, but it typically does not integrate well with typing and pointing because the stylus must be put down somewhere or held awkwardly during other input activities. Also, it may be difficult to distinguish the handwriting activity of the stylus from pointing motions of a fingertip. Thus there exists a need in the art for a method to capture coarse handwriting gestures without a stylus and without confusing them with pointing motions.

Many of the input differentiation needs cited above could be met with a touch sensing technology which distinguishes a variety of hand configurations and motions such as sliding finger chords and grips. Many mechanical chord keyboards have been designed to detect simultaneous downward activity from multiple fingers, but they do not detect lateral finger motion over a large range. Related art shows several examples of capacitive touchpads which emulate a mouse or keyboard by tracking a single finger. These typically measure the capacitance of or between elongated wires which are laid out in rows and columns. A thin dielectric is interposed between the row and column layers. Presence of a finger perturbs the self or mutual capacitance for nearby electrodes. Since most of these technologies use projective row and column sensors which integrate on one electrode the proximity of all objects in a particular row or column, they cannot uniquely determine the positions of two or more objects as discussed in S. Lee, "A Fast Multiple-Touch-Sensitive Input Device," University of Toronto Masters Thesis (1984). The best they can do is count fingertips which happen to lie in a straight row, and even that will fail if a thumb or palm is introduced in the same column as a fingertip.

In U.S. Pat. Nos. 5,565,658 and 5,305,017, Gerpheide et al. measure the mutual capacitance between row and column electrodes by driving one set of electrodes at some clock