MULTIPLE FINGERS CONTACT SENSING METHOD FOR EMULATING MOUSE BUTTONS AND MOUSE OPERATIONS ON A TOUCH SENSOR PAD

RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 08/582,768, filed Jan. 4, 1996, abandoned.

FIELD OF THE INVENTION

The present invention relates generally to touchpad devices, and more particularly relates to touchpad devices which detect at least the presence of one or more objects such as fingers to effectuate preselected control functions.

BACKGROUND OF THE INVENTION

Touch sensing devices are well known, and take a number of different forms. Perhaps the best known are resistive-membrane position sensors, which have been used in a number of different applications for many years. Such devices have been used as keyboards, position indicators, and so forth. Other types of touch sensing devices include resistive tablets, surface acoustic wave devices, touch sensors based on strain gages or pressure sensors, and optical sensors.

Yet another touch sensing technology is capacitive sensing, in which the location of a finger (or in some instances another object such as a stylus) over a sensing device is determined by virtue of variations in capacitance under and around the location of the finger. Typical of capacitive touch sensing devices are touch screens and capacitive pads which employ a matrix of row and column electrodes and detect, for example, either the transcapacitance between row and column electrodes or the effective capacitance to virtual ground. Other capacitive techniques are also known. Some touch sensitive devices are known to use interpolation for more precisely identifying the location of a finger or stylus.

Typical of each of these prior art devices is that each of them senses any contact as that of only one finger at a time. Cursor movement is straightforward with one finger, and tapping of a finger on the surface of the pad can be detected and acted upon in a manner similar to detecting the actuation of a button on a mouse. Single and double taps can be used as simple equivalents of single and double mouse clicks.

With a single-finger touchpad, the click and drag function is more difficult. With single finger detection, dragging has been implemented with schemes such as uptap (finger lifted and placed down again quickly), tap-and-a-half, and sticky drag (drag lock turns on automatically after the finger is placed in one location without moving for more than a certain time, such as one second). All of these methods take more time and/or more finger motions than it takes to perform the equivalent function with a mouse, and are not intuitive to users familiar with electronic mice. Prior art touch pads are thus less attractive for general use than a mouse.

Another commonly used function in the prior art is that of clicking a box (or icon or displayed "button") or series of boxes (such as "connecting the dots"). With a mouse, the cursor is moved into position by moving the mouse, then the click occurs with a down-up motion of the finger to actuate a button or switch. With a touchpad typical of the prior art, the cursor is moved into position with the finger, then the click occurs with a tap of the finger which moved the cursor.

This requires an up-down-up-down finger motion to do the same thing as simply the "down-up" motion of the mouse button. In general, any touchpad equivalent to a mouse button-clicking function requires an extra "up . . . up" motion of the finger, because the finger must be lifted off the pad before and after the tap.

The time and stress associated with the extra motion is significant. Human factors studies have shown that such touchpads yield lower productivity than a mouse in many applications. This somewhat limits touchpads to those applications, such as portable computing, where use of a mouse is inconvenient due to space or other considerations. There is therefore a need for a touchpad capable of yielding the same productivity as a mouse.

SUMMARY OF THE INVENTION

The present invention provides a novel method and apparatus for sensing the proximity of multiple simultaneous fingers or other appropriate objects to a touch sensor. The present invention may be implemented based on any conventional touch sensing technology, although an exemplary embodiment involves the use of a capacitive touch sensing device similar to that described in U.S. patent application Ser. No. 08,478,290, entitled Touch Sensing Method and Apparatus, filed Jun. 7, 1995, and assigned to the assignee of the present application. The numerous modifications to such a basic device required to implement the present invention are described generally below, and in detail hereinafter. Alternatively, the present invention may be used with the method and apparatus described in the U.S. patent application Ser. No. 08/582,769, entitled Touch Pad Sensing Method and Apparatus, having as inventors Bemi Joss, Bernard Kasser and Stephen Bisset, filed on Jan. 4, 1996, and assigned to the assignee of the present invention, the relevant portions of which are incorporated herein by reference.

Operation of the present invention includes two aspects: detection of multiple objects, typically fingers, and assignment of various functions to particular actions by the movement of one or both fingers. The detection function can be general, but in a simple, exemplary implementation can be limited to a two-finger function such as the combination of the index finger and middle finger. In general, these are the two most dextrous fingers, and they work well together. As a result, for this exemplary embodiment, the touchpad need only distinguish between the two fingers in one dimension since the two fingers are typically side by side. In addition, the touchpad need only detect the second finger in reasonably close proximity to the first finger. In most situations, the distance between finger centers will be less than five centimeters. Additional combinations of fingers, such as three fingers tapping simultaneously or other combinations, may also be implemented in accordance with the methodology of the present invention.

For clarity of explanation, the present invention can be described in most of its applications by establishing one finger as controlling movement of the cursor, and the second finger as controlling functions equivalent to a mouse button or switch. In this context, one finger may be considered the "point" finger, while the other is the "click" finger. Various conventional functions may then be defined accordingly. For example, "drag" may be effected by moving the two fingers in unison, "point and click" may be effected by moving the cursor with the first finger and tapping with the second finger, "point and double click" may be effected by moving the cursor with the first finger and double tapping with the