MULTI-TOUCH CONTACT TRACKING ALGORITHM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of Ser. No. 11/015,434, entitled "Method and Apparatus for Integrating Manual Input," filed Dec. 17, 2004, which is a continuation of Ser. No. 09/919,266 (now U.S. Pat. No. 6,888,536), entitled "Method And Apparatus For Integrating Manual Input" filed Jul. 31, 2001, which is a division of application Ser. No. 09/236,513 (now U.S. Pat. No. 6,323,846) filed Jan. 25, 1999 which claims the benefit of provisional application 60/072,509, filed Jan. 26, 1998, each of which is hereby incorporated by reference in its entirety. This application is also related to application Ser. No. 11/428,501 entitled "Capacitive Sensing Arrangement (atty ref. FW-0092USC2), Ser. No. 11/428,503 entitled "Touch Surface (atty. ref. FW-0092USC3), Ser. No. 11/428,506 entitled "User Interface Gestures (atty. ref. FW-0092USC4), Ser. No. 11/428,515 entitled "User Interface Gestures" (atty. ref. FW-0092USC5), Ser. No. 11/428,522 entitled "Identifying Contacts on a Touch Surface (atty. ref. FW-0092USC6), Ser. No. 11/428,521 entitled "Identifying Contacts on a Touch Surface" (atty. Ref. FW-0092USC7), Ser. No. _____ entitled "Multi-Touch Contact Motion Extraction" (atty. Ref. FW-0092USC9), Ser. No. _____ entitled "Multi-Touch Contact Motion Extraction" (atty. Ref. FW-0092USA), Ser. No. _____ entitled "Multi-Touch Contact Motion Extraction" (atty. Ref. FW-0092USB), Ser. No. _____ entitled "Multi-Touch Hand Position Offset Computation" (atty. Ref. FW-0092USC), each of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] A. Field of the Invention

[0003] The present invention relates generally to methods and apparatus for data input, and, more particularly, to a method and apparatus for integrating manual input.

[0004] B. Description of the Related Art

[0005] Many methods for manual input of data and commands to computers are in use today, but each is most efficient and easy to use for particular types of data input. For example, drawing tablets with pens or pucks excel at drafting, sketching, and quick command gestures. Handwriting with a stylus is convenient for filling out forms which require signatures, special symbols, or small amounts of text, but handwriting is slow compared to typing and voice input for long documents. Mice, finger-sticks and touchpads excel at cursor pointing and graphical object manipulations such as drag and drop. Rollers, thumbwheels and trackballs excel at panning and scrolling. The diversity of tasks that many computer users encounter in a single day call for all of these techniques, but few users will pay for a multitude of input devices, and the separate devices are often incompatible in a usability and an ergonomic sense. For instance, drawing tablets are a must for graphics professionals, but switching between drawing and typing is inconvenient because the pen must be put down or held awkwardly between the fingers while typing. Thus, there is a long-felt need in the art for a manual input device which is cheap yet offers convenient integration of common manual input techniques.

[0006] Speech recognition is an exciting new technology which promises to relieve some of the input burden on user hands. However, voice is not appropriate for inputting all types of data either. Currently, voice input is best-suited for dictation of long text documents. Until natural language recognition matures sufficiently that very high level voice commands can be understood by the computer, voice will have little advantage over keyboard hot-keys and mouse menus for command and control. Furthermore, precise pointing, drawing, and manipulation of graphical objects is difficult with voice commands, no matter how well speech is understood. Thus, there will always be a need in the art for multi-function manual input devices which supplement voice input.

[0007] A generic manual input device which combines the typing, pointing, scrolling, and handwriting capabilities of the standard input device collection must have ergonomic, economic, and productivity advantages which outweigh the unavoidable sacrifices of abandoning device specialization. The generic device must tightly integrate yet clearly distinguish the different types of input. It should therefore appear modeless to the user in the sense that the user should not need to provide explicit mode switch signals such as buttonpresses, arm relocations, or stylus pickups before switching from one input activity to another. Epidemiological studies suggest that repetition and force multiply in causing repetitive strain injuries. Awkward postures, device activation force, wasted motion, and repetition should be minimized to improve ergonomics. Furthermore, the workload should be spread evenly over all available muscle groups to avoid repetitive strain.

[0008] Repetition can be minimized by allocating to several graphical manipulation channels those tasks which require complex mouse pointer motion sequences. Common graphical user interface operations such as finding and manipulating a scroll bar or slider control are much less efficient than specialized finger motions which cause scrolling directly, without the step of repositioning the cursor over an on-screen control. Preferably the graphical manipulation channels should be distributed amongst many finger and hand motion combinations to spread the workload. Touchpads and mice with auxilliary scrolling controls such as the Cirque®™ Smartcat touchpad with edge scrolling, the IBM®™ ScrollPoint™ mouse with embedded pointing stick, and the Roller Mouse described in U.S. Pat. No. 5,530,455 to Gillick et al. represent small improvements in this area, but still do not provide enough direct manipulation channels to eliminate many often-used cursor motion sequences. Furthermore, as S. Zhai et al. found in "Dual Stream Input for Pointing and Scrolling," Proceedings of CHI '97 Extended Abstracts (1997), manipulation of more than two degrees of freedom at a time is very difficult with these devices, preventing simultaneous panning, zooming and rotating.

[0009] Another common method for reducing excess motion and repetition is to automatically continue pointing or scrolling movement signals once the user has stopped moving or lifts the finger. Related art methods can be distinguished by the conditions under which such motion continuation is enabled. In U.S. Pat. No. 4,734,685, Watanabe continues image panning when the distance and velocity of pointing device movement exceed thresholds. Automatic panning is, stopped by moving the pointing