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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G09G 5/00

A1

(11) International Publication Number: **WO 99/38149**

(43) International Publication Date: 29 July 1999 (29.07.99)

(21) International Application Number: PCT/US99/01454

(22) International Filing Date: 25 January 1999 (25.01.99)

(30) Priority Data:

60/072,509	26 January 1998 (26.01.98)	US
09/236,513	25 January 1999 (25.01.99)	US

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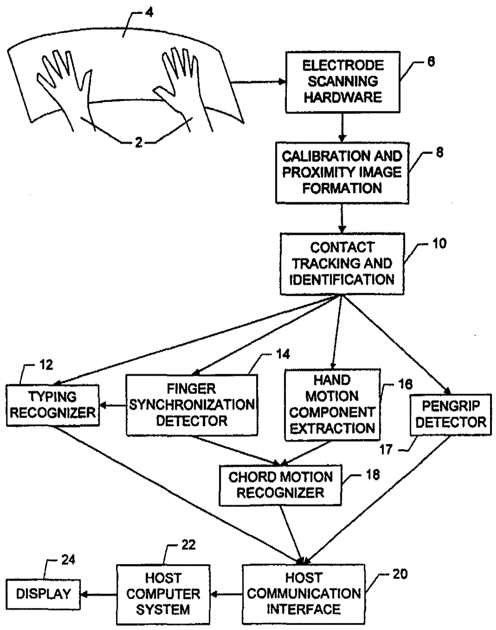
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR INTEGRATING MANUAL INPUT

(57) Abstract

Apparatus and methods are disclosed for simultaneously tracking multiple finger (202–204) and palm (206, 207) contacts as hands approach, touch, and slide across a proximity–sensing, compliant, and flexible multi–touch surface (2). The surface consists of compressible cushion (32), dielectric electrode (33), and circuitry layers. A simple proximity transduction circuit is placed under each electrode to maximize the signal–to–noise ratio and to reduce wiring complexity. Scanning and signal offset removal on electrode array produces low–noise proximity images. Segmentation processing of each proximity image constructs a group of electrodes corresponding to each distinguishable contacts and extracts shape, position and surface proximity features for each group. Groups in successive images which correspond to the same hand contact are linked by a persistent path tracker (245) which also detects individual contact touchdown and liftoff. Classification of intuitive hand configurations and motions enables unprecedented integration of typing, resting, pointing, scrolling, 3D manipulation, and handwriting into a versatile, ergonomic computer input device.



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METHOD AND APPARATUS FOR INTEGRATING MANUAL INPUT

BACKGROUND OF THE INVENTION

The present application is based upon U.S. provisional patent application Serial No. 60/072,509, filed January 26, 1998, and the U.S. utility application Serial No. 09,236,513, filed January 25, 1999.

A. Field of the Invention

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

B. Description of the Related Art

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.

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.

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.

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. Patent 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.

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. Patent 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 device back in the opposite direction, so stopping requires additional precise movements. In U.S. Patent No. 5,543,591 to Gillespie et al., motion continuation occurs when the finger enters an edge border region around a small touchpad. Continued motion speed is fixed and the direction corresponds to the direction from the center of the touchpad to the finger at the edge. Continuation mode ends when the finger leaves the border region or lifts off the pad. Disadvantageously, users sometimes pause at the edge of the pad without intending for cursor motion to continue, and the unexpected motion continuation becomes annoying. U.S. Patent No. 5,327,161 to Logan et al. describes motion continuation when the finger enters a border area as well, but in an alternative trackball emulation mode, motion continuation can be a function solely of lateral finger velocity and direction at liftoff. Motion continuation decays due to a friction factor or can be stopped by a subsequent touchdown on the surface. Disadvantageously, touch velocity at liftoff is not a reliable indicator of the user's desire for motion continuation since when approaching a large target on a display at high speeds the user may not stop the pointer completely before liftoff. 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 don't have to leave typing position to access the pointing device. These include the integrated pointing key described in U.S. Patent 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. Patent 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. No. Patent 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

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