[0073] **FIG. 24** is a Voronoi cell diagram constructed around hand part attractor points;

[0074] **FIG. 25A** is a plot of orientation weighting factor for right thumb, right inner palm, and left outer palm versus contact orientation;

[0075] **FIG. 25B** is a plot of thumb size factor versus contact size;

[0076] **FIG. 25C** is a plot of palm size factor versus ratio of total contact proximity to contact eccentricity;

[0077] **FIG. 25D** is a plot of palm separation factor versus distance between a contact and it nearest neighbor contact;

[0078] **FIG. 26** is a flow chart of the thumb presence verification algorithm;

[0079] **FIG. 27** is a flow chart of an alternative hand part identification algorithm;

[0080] **FIG. 28** is a flow chart of the pen grip detection process:

[0081] **FIG. 29** is a flow chart of the hand identification algorithm:

[0082] FIGS. **30**A-C show three different hand partition hypotheses for a fixed arrangement of surface contacts;

[0083] **FIG. 31A** is a plot of the hand clutching direction factor versus horizontal hand velocity;

[0084] **FIG. 31B** is a plot of the handedness factor versus vertical position of outermost finger relative to next outermost;

[0085] **FIG. 31C** is a plot of the palm cohesion factor versus maximum horizontal separation between palm contacts within a hand;

[0086] **FIG. 32** is a plot of the inner finger angle factor versus the angle between the innermost and next innermost finger contacts;

[0087] **FIG. 33** is a plot of the inter-hand separation factor versus the estimated distance between the right thumb and left thumb;

[0088] **FIG. 34** is a flow chart of hand motion component extraction;

[0089] **FIG. 35** is a diagram of typical finger trajectories when hand is contracting;

[0090] **FIG. 36** is a flow chart of radial and angular hand velocity extraction;

[0091] **FIG. 37** is a flow chart showing extraction of translational hand velocity components;

[0092] **FIG. 38** is a flow chart of differential hand pressure extraction;

[0093] **FIG. 39A** is a flow chart of the finger synchronization detection loop;

[0094] **FIG. 39B** is a flow chart of chord tap detection;

[0095] **FIG. 40A** is a flow chart of the chord motion recognition loop;

[0096] **FIG. 40B** is a flow chart of chord motion event generation;

[0097] **FIG. 41** is a flow chart of key layout morphing;

[0098] **FIG. 42** is a flow chart of the keypress detection loop;

[0099] **FIG. 43A** is a flow chart of the keypress acceptance and transmission loop; and

[0100] **FIG. 43B** is a flow chart of typematic emulation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0101] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0102] **FIG. 1** is a system block diagram of the entire, integrated manual input apparatus. Sensor embedded in the multi-touch surface **2** detect proximity of entire flattened hands **4**, fingertips thumbs, palms, and other conductive touch devices to the surface **2**. In a preferred embodiment, the surface is large enough to comfortably accommodate both hands **4** and is arched to reduce forearm pronation.

[0103] In alternative embodiments the multi-touch surface **2** may be large enough to accommodate motion of one hand, but may be flexible so it can be fitted to an armrest or clothing.

[0104] Electronic scanning hardware **6** controls and reads from each proximity sensor of a sensor array. A calibration module **8** constructs a raw proximity image from a complete scan of the sensor array and subtracts off any background sensor offsets. The background sensor offsets can simply be a proximity image taken when nothing is touching the surface.

[0105] The offset-corrected proximity image is then passed on to the contact tracking and identification module **10**, which segments the image into distinguishable hand-surface contacts, tracks and identifies them as they move through successive images.

[0106] The paths of identified contacts are passed on to a typing recognizer module **12**, finger synchronization detection module **14**, motion component extraction module **16**, and pen grip detection module **17**, which contain software algorithms to distinguish hand configurations and respond to detected hand motions.

[0107] The typing recognizer module **12** responds to quick presses and releases of fingers which are largely asynchronous with respect to the activity of other fingers on the same hand. It attempts to find the key region nearest to the location of each finger tap and forwards the key symbols or commands associated with the nearest key region to the communication interface module **20**.

[0108] The finger synchronization detector **14** checks the finger activity within a hand for simultaneous presses or releases of a subset of fingers. When such simultaneous activity is detected it signals the typing recognizer to ignore or cancel keystroke processing for fingers contained in the synchronous subset. It also passes on the combination of finger identities in the synchronous subset to the chord motion recognizer **18**.