[0040] To even further achieve the objects, the present invention comprises a multi-touch surface apparatus for sensing diverse configurations and activities of fingers and palms of one or more hands near the surface and generating integrated manual input to one of an electronic or electromechanical device, the apparatus comprising: an array of proximity sensing means embedded in the surface; scanning means for forming digital proximity images from the proximities measured by the sensing means; image segmentation means for collecting into groups those proximity image pixels intensified by contact of the same distinguishable part of a hand; contact tracking means for parameterizing hand contact features and trajectories as the contacts move across successive proximity images, contact identification means for determining which hand and which part of the hand is causing each surface contact; synchronization detection means for identifying subsets of identified contacts which touchdown or liftoff the surface at approximately the same time, and for generating command signals in response to synchronous taps of multiple fingers on the surface; typing recognition means for generating intended key symbols from asynchronous finger taps; motion component extraction means for compressing multiple degrees of freedom of multiple fingers into degrees of freedom common in two and three dimensional graphical manipulation; chord motion recognition means for generating one of command and cursor manipulation signals in response to motion in one or more extracted degrees of freedom by a selected combination of fingers; pen grip detection means for recognizing contact arrangements which resemble the configuration of the hand when gripping a pen, generating inking signals from motions of the inner fingers, and generating cursor manipulation signals from motions of the palms while the inner fingers are lifted; and communication means for sending the sensed configurations and activities of finger and palms to one of the electronic and electromechanical device.

[0041] To further achieve the objects, the present invention comprises a method for tracking and identifying hand contacts in a sequence of proximity images in order to support interpretation of hand configurations and activities related to typing, multiple degree-of-freedom manipulation via chords, and handwriting, the method comprising the steps of: segmenting each proximity image into groups of electrodes which indicate significant proximity, each group representing proximity of a distinguishable hand part or other touch device; extracting total proximity, position, shape, size, and orientation parameters from each group of electrodes; tracking group paths through successive proximity images including detection of path endpoints at contact touchdown and liftoff; computing velocity and filtered position vectors along each path; assigning a hand and finger identity to each contact path by incorporating relative path positions and velocities, individual contact features, and previous estimates of hand and finger positions; and maintaining estimates of hand and finger positions from trajectories of paths currently assigned to the fingers, wherein the estimates provide high level feedback to bias segmentations and identifications in future images.

[0042] To still further achieve the objects, the present invention comprises a method for integrally extracting multiple degrees of freedom of hand motion from sliding motions of two or more fingers of a hand across a multi-touch surface, one of the fingers preferably being the opposable thumb, the method comprising the steps of: tracking across successive scans of the proximity sensor array the trajectories of individual hand parts on the surface; finding an innermost and an outermost finger contact from contacts identified as fingers on the given hand; computing a scaling velocity component from a change in a distance between the innermost and outermost finger contacts; computing a rotational velocity component from a change in a vector angle between the innermost and outermost finger contacts; computing a translation weighting for each contacting finger; computing translational velocity components in two dimensions from a translation weighted average of the finger velocities tangential to surface; suppressively filtering components whose speeds are consistently lower than the fastest components; transmitting the filtered velocity components as control signals to an electronic or electromechanical device.

[0043] To even further achieve the objects, the present invention comprises a manual input integration method for supporting diverse hand input activities such as resting the hands, typing, multiple degree-of-freedom manipulation, command gesturing and handwriting on a multi-touch surface, the method enabling users to instantaneously switch between the input activities by placing their hands in different configurations comprising distinguishable combinations of relative hand contact timing, proximity, shape, size, position, motion and/or identity across a succession of surface proximity images, the method comprising the steps of: tracking each touching hand part across successive proximity images; measuring the times when each hand part touches down and lifts off the surface; detecting when hand parts touch down or lift off simultaneously; producing discrete key symbols when the user asynchronously taps, holds, or slides a finger on key regions defined on the surface; producing discrete mouse button click commands, key commands, or no signals when the user synchronously taps two or more fingers from the same hand on the surface; producing gesture commands or multiple degree-of-freedom manipulation signals when the user slides two or more fingers across the surface; and sending the produced symbols, commands and manipulation signals as input to an electronic or an electro-mechanical device.

[0044] To still even further achieve the objects, the present invention comprises a method for choosing what kinds of input signals will be generated and sent to an electronic or electromechanical device in response to tapping or sliding of fingers on a multi-touch surface, the method comprising the following steps: identifying each contact on the surface as either a thumb, fingertip or palm; measuring the times when each hand part touches down and lifts off the surface; forming a set of those fingers which touch down from the all finger floating state before any one of the fingers lifts back off the surface; choosing the kinds of input signals to be generated by further distinctive motion of the fingers from the combination of finger identities in the set; generating input signals of this kind when further distinctive motions of the fingers occur; forming a subset any two or more fingers which touch down synchronously after at least one finger has lifted back off the surface; choosing a new kinds of input signals to be generated by further distinctive motion of the fingers from the combination of finger identities in the subset; generating input signals of this new kind when further distinctive motions of the fingers occur; and continuing to form new subsets, choose and generate new kinds of input signals in response to liftoff and synchronous touchdowns until all fingers lift off the surface.