

layout, the position of the key symbols in these embodiments of the multi-touch surface would not be printed permanently on the surface. Instead, the position of the key symbols would be reprogrammably displayed on the surface by light emitting polymers, liquid crystal, or other dynamic visual display means embedded in the multi-touch surface apparatus along with the proximity sensor arrays.

[0277] Given such an apparatus, step 702 retrieves the current paths from both hands and awaits what will be known as a layout homing gesture. If decision diamond 704 decides with the help of, a hand's synchronization detector that all five of the hand's fingers have just been placed on the surface synchronously, step 706 will attempt to snap the key layout to the hand such that the hand's home row keys lie under the synchronized fingertips, wherever the hand is on the surface. Step 706 retrieves the measured hand offsets from the hand position estimator and translates all key regions which are normally typed by the given hand in proportion to the measured hand offsets. Note the currently measured rather than filtered estimates of offsets can be used because when all five fingers are down there is no danger of finger misidentification corrupting the measured offsets. This procedure assumes that the untranslated locations of the home row keys are the same as the default finger locations for the hand.

[0278] Decision diamond 708 checks whether the fingers appear to be in a neutral, partially closed posture, rather closed than outstretched or pinched together. If the posture is close to neutral, step 710 may further offset the keys normally typed by each finger, which for the most part are the keys in the same column of the finger by the measured finger offsets. Temporal filtering of these finger offsets over several layout homing gestures will tend to scale the spacing between columns of keys to the user's hand size. Spacing between rows is scaled down in proportion to the scaling between columns.

[0279] With the key layout for the hand's keys morphed to fit the size and current position of the resting hand, step 712 updates the displayed position of the symbols on the surface, so that the user will see that the key layout has snapped to the position of his hand. From this stage the user can begin to type and the typing recognizer 718 will use the morphed key region locations to decide what key regions are being pressed. The layout will remain morphed this way until either the user performs another homing gesture to move it somewhere else on the surface, or until the user takes both hands off the surface for a while. Decision diamond 714 will eventually time out so that step 716 can reset the layout to its default position in readiness for another user or usage session.

[0280] For smaller multi-touch surfaces in which the key layout is permanently printed on the surface, it is advantageous to give the user tactile feedback about the positions of key regions. However, any tactile indicators placed on the surface must be carefully designed so as not to impede smooth sliding across the surface. For example, shallow depressions made in the surface near the center of each key mimicking the shallow depressions common on mechanical keyboard keycaps would cause a vibratory washboard effect as the hand slides across the surface. To minimize such washboard effects, in the preferred embodiment the multi-touch surface provides for the fingertips of each hand a single, continuous depression running from the default index fingertip location to the default pinky fingertip location. This corresponds on the QWERTY key layout to shallow, slightly arched channels along home row from the "J" key to the ";" key for the right hand, and from the "A" key to the "F" key for

the left hand. Similarly, the thumbs can each be provided with a single oval-shaped depression at their default locations, slanted slightly from vertical to match the default thumb orientation. These would preferably correspond to "Space" and "BackSpace" key regions for the right and left thumbs, respectively. Such minimal depressions can tactilely guide users' hands back to home row of the key layout without requiring users to look down at the surface and without seriously disrupting finger chord slides and manipulations on the surface.

[0281] The positions of key regions off home row can be marked by other types of tactile indicators. Simply roughening the surface at key regions does not work well. Though humans easily differentiate textures when sliding fingers over them, most textures cannot be noticed during quick taps on a textured region. Only relatively abrupt edges or protrusions can be sensed by the users' fingertips under typing conditions. Therefore, a small raised dot like a Braille dot is formed on top of the surface at the center of each key region. The user receives feedback on the accuracy of their typing strokes from where on the fingertip a dot is felt. This feedback can be used to correct finger aim during future keypresses. Since single finger slides are ignored by the chord motion recognizer, the user can also slide a finger around the surface in tactile search of a particular key region's dot and then tap the key region when the dot is found, all without looking at the surface. Each dot should be just: large enough to be felt during tapping but not so large as to impede chord slides across the surface. Even if the dots are not large enough to impede sliding, they can still corrupt proximity and fingertip centroid measurements by raising the fingertip flesh near the dot off the surface thus locally separating the flesh from the underlying proximity sensing electrode. Therefore, in the preferred embodiment, the portion of each dot above the surface dielectric is made of a conductive material. This improves capacitive coupling between the raised fingertip flesh and the underlying electrodes.

[0282] FIG. 42 shows the steps within the keypress detection loop. Step 750 retrieves from the current identified path data 250 any paths which were recently created due to hand part touchdown or the surface. Decision diamond 752 checks whether the path proximity reached a keypress proximity thresh for the first time during the current sensor array scan. If the proximity has not reached the threshold yet or has already exceeded it previously, control returns to step 750 to try keypress detection on the next recent path. If the path just crossed the keypress proximity threshold decision diamond 754 checks whether the contact path has been identified as a finger rather than a palm. To give the users the freedom rest the palms anywhere on the surface, palm presses should not normally cause keypresses, and are therefore ignored. Assuming the path is a finger, decision diamond 756 checks whether the hand the identified finger comes from is currently performing a chord slide gesture or writing via the pen grip hand configuration. Asynchronous finger presses are ignored once these activities have started, as also indicated in step 660 of FIG. 40A. Assuming such hand activities are not ongoing, decision diamond 757 proceeds with debounce tests which check that the finger has touched the surface for at least two sensor array scan cycles and that it had been off the surface for several scan cycles before touching down. The path tracking module (FIG. 22) facilitates such liftoff debouncing by reactivating in step 334 a finger's old path if the finger lifts off and quickly touches back down over the same spot. Upon reacti-