

remain static. Additional aspects of sequential selective tracking of subsets of parameters are taught in pending U.S. Patent Application 61/363,272.

**[0312]** In one example aspect of sequential selective tracking of subsets of parameters, the parameters tracked at any particular moment can include one or more of left-right geometric center (“x”), forward-back geometric center (“y”), average downward pressure (“p”), clockwise-counterclockwise pivoting yaw angular rotation (“ψ”), tilting roll angular rotation (“φ”), and tilting pitch angular rotation (“θ”) parameters calculated in real time from sensor measurement data. Typically the left-right geometric center (“x”), forward-back geometric center (“y”) measurements are essentially independent and these can be tracked together if none of the other parameters only undergo minor spurious variation. An exemplary classification under such conditions could be {x,y}. For example, FIG. 43 depicts two exemplary intervals of time wherein the {x,y} classification is an estimated outcome.

**[0313]** In another example aspect of sequential selective tracking of subsets of parameters, other motions of the finger or parts of the hand can invoke variations of not only the intended parameter but also variation in one or more other “collateral” parameters as well. One example of this is tilting roll angular rotation (“φ”), where rolling the finger from a fixed left-right position nonetheless causes a correlated shift in the measured and calculated left-right geometric center (“x”). In an embodiment, the classification system discerns between a pure tilting roll angular rotation (“φ”) with no intended change in left-right position (classified for example as {φ}) from a mixed tilting roll angular rotation with an intended change in left-right position (classified for example as {φ x}). A similar example is the tilting pitch angular rotation (“θ”), where pitching the finger from a fixed forward-back position nonetheless causes a correlated shift in the measured and calculated forward-back geometric center (“y”). In an embodiment, the classification system discerns between a pure tilting pitch angular rotation (“θ”) with no intended change in forward-back position (classified for example as {θ}) from a mixed tilting roll angular rotation with an intended change in forward-back position (classified for example as {θ y}). FIG. 43 depicts an exemplary interval of time wherein the {θ} classification is an estimated outcome and an exemplary interval of time wherein the {θ y} classification is an estimated outcome.

**[0314]** In a similar fashion, the invention provides for embodiments to include classifications for isolated changes in pressure {p} and isolated changes in yaw angle {ψ}. (Should it be useful, the invention also provides for embodiments to include classifications pertaining to isolated changes in left-right position {x} and/or isolated changes in forward-back position {y}.) Also in a similar fashion, the invention provides for embodiments to include classifications pertaining to other pairs of simultaneous parameter variations, for example such as but not limited to {x,p}, {y,p}, {θ,ψ}, {θ,p}, {θ x}, {φ,θ}, {φ,ψ}, {θ,ψ}, {φ,p}, {φ,y}, {ψ,x}, {ψ y}, etc. Further, the invention provides for embodiments to include classifications pertaining to one or more of:

- [0315]** three simultaneous parameter variations,
- [0316]** four simultaneous parameter variations,
- [0317]** five simultaneous parameter variations,
- [0318]** six simultaneous parameter variations,
- [0319]** more than six simultaneous parameter variations.

**[0320]** HDTP Information Processing Functions and Operations which can be Implemented by One or More ANN(s)

**[0321]** As described thus far, one or more ANN(s) can provide a wide variety of functions to HDTP information processing including but not limited to:

**[0322]** Various types of signal processing and image analysis functions (for example as utilized in machine vision):

- [0323]** Noise removal;
- [0324]** Various types of data normalization;
- [0325]** Primitive segmentation;
- [0326]** Pattern analysis and classification;
- [0327]** Shape analysis and classification;
- [0328]** Consistency analysis;
- [0329]** Pattern matching;
- [0330]** Shape matching;
- [0331]** Post shape-analysis segment re-aggregation;
- [0332]** Feature measurement;
- [0333]** Statistical analysis;

**[0334]** Gestures recognition generated from values of pseudo-continuous parameter values calculated from frames;

**[0335]** Sliding window computation and reasoning.

**[0336]** Additionally, an ANN can be used to provide additional computation functions to the HDTP signal flow, including but not limited to:

- [0337]** Time series analysis;
- [0338]** Curve fitting to tactile imprint parts such as data gradient boundaries or edges as detected using edge detection algorithms;
- [0339]** Bayesian analysis of histograms.

**[0340]** By way of illustration, examples of elementary gestures that can be recognized by an ANN as provided for by the invention include but are not limited to:

**[0341]** discrete pressing events (changing vertically-applied pressure by finger contact with touchpad, without moving finger to other locations on the tactile sensor surface)

**[0342]** yaw rotation—(for example changing pivot angle of finger at point of finger contact with touchpad, without moving finger to other locations on the tactile sensor surface)

**[0343]** up-down tilt or pitch (changing up-down angle of finger at point of finger contact with touchpad, without moving finger to other locations on the tactile sensor surface)

**[0344]** left-right tilt or roll (changing left-right rolling angle of finger at point of finger contact with touchpad, without moving finger to other locations on the tactile sensor surface)

**[0345]** click (quickly tapping touchpad with a finger)

**[0346]** double-click (two quick, consecutive taps of touchpad with a finger)

**[0347]** multi-finger specific motions.

However, an ANN can be used to recognize for more sophisticated and subtle gestures.

**[0348]** Example ANN-Internal Attributes

**[0349]** A variety of ANN types can be used, including but not limited to for example:

- [0350]** Feed-forward (back propagation) network with multiple hidden layers;
- [0351]** Radial basis function.