

CLAIMS

What is claimed is:

1. A system for measuring latency at any of a plurality of points on a device which includes a touch surface that receives user input and provides graphical output in response thereto, comprising:
 - a body separate from the device, the body having a proximal end and a distal end;
 - at least one contact sensor operatively attached to the distal end of the body for detecting a touch event input to the device at a first time;
 - at least one graphical change sensor for detecting a graphical response output from the device at a second time, the response being responsive to the touch event;
 - a computational engine operatively connected to the at least one contact sensor and the at least one graphical change sensor, the computational engine for computing a time differential between the first time and the second time; and,
 - an output configured to identify a measurement of latency between the touch event and a graphical response in the device, the measurement being reflective of the time differential between the first time and the second time.
2. A system for measuring latency in a device which includes a user interface that receives user input and provides output in response thereto, comprising:
 - a body separate from the device, the body having a proximal end and a distal end;
 - a first sensor operatively attached to the distal end of the body for detecting a touch event input to the device at a first time;
 - a second sensor for detecting a response output from the device at a second time, the response being responsive to the touch event;
 - circuitry operatively connected to the first sensor and the second sensor configured to output time data reflective of a measurement of latency between detecting a touch event by the first sensor and detecting a response by the second sensor; and,

| a communication interface configured to transmit the time data to the device for processing the time data and displaying a latency.

3. A method for measuring latency at a plurality of points on a device, the device having a user interface that receives user input and provides output in response thereto, the method comprising:

receiving, via a communication interface on the device, time data from an external time data generator that generates first data representing a first time at which a touch event is created and a second time at which the device outputs a response to the touch event, the time data being reflective of a measurement of latency between the first time and the second time;

using the time data received via the communication interface to determine a latency associated with the device; and,

displaying the latency on a display of the device.

4. A system for measuring latency on a device which includes a user interface that receives touch input and provides output in response thereto, comprising:

a body separate from the device;

a first sensor operatively attached to the body for detecting a touch event input to the device at a first time;

a second sensor for detecting a response output from the device at a second time, the response being responsive to the touch event;

a computational engine for computing a time differential between the first time and the second time; and,

| an output device configured to output an indication of a measurement of latency in the device, the measurement being reflective of the time differential between the first time and the second time.

5. The system for measuring latency of claim 4, wherein the body comprises a proximal end and a distal end, the proximal end of the body being shaped to be operable as a handle and the distal end

19. The system for measuring latency of claim 17, wherein the photodetector comprises at least one selected from the group consisting of: an active pixel sensor, a charge-coupled device, a photoresistor, a photovoltaic cell, a photodiode, photomultiplier, phototube or quantum-dot photoconductor.
20. The system for measuring latency of claim 4, wherein the device is a smart phone, tablet or computer.
21. The system for measuring latency of claim 4, wherein the system is configured to display latency in a sensing/processing/display.
22. The system for measuring latency of claim 4, wherein the device is a touch-sensitive device.
23. The system for measuring latency of claim 4, wherein the device is a multi-touch-sensitive device.
24. The system for measuring latency of claim 4, wherein the device is a stylus-sensitive device.
25. The system for measuring latency of claim 22, wherein the device is a stylus-sensitive device.
26. The system for measuring latency of claim 23, wherein the device is a stylus-sensitive device.
27. The system for measuring latency of claim 4, wherein the first sensor and the second sensor are selected or configured such that a latency associated with the first sensor and a latency associated with the second sensor, taken together, are less than the latency of the device.
28. The system for measuring latency of claim 4, wherein the measurement of latency is created at least in part by subtracting a time delay that is due to internal components of the system from the time differential.
29. The system for measuring latency of claim ~~25~~28, wherein the time delay that is due to internal components of the system is fixed.
30. The system for measuring latency of claim ~~25~~28, wherein the time delay that is due to internal components of the system is detected.
31. The system for measuring latency of claim ~~25~~28, wherein the time delay that is due to internal components of the system is estimated.

32. The system for measuring latency of claim 4, wherein the computational engine comprises at least one selected from the group consisting of:
- a system-on-a-chip, a central-processing unit, a micro-controller-unit, a field-programmable gate-array, a NAND memory, a vertical NAND memory, a random-access memory, a resistive random-access memory or a magneto-resistive random-access memory.
33. The system for measuring latency of claim 13, further comprising a light source configured to illuminate a display area of the device.
34. The system for measuring latency of claim 4, wherein the output comprises a read-out display.
35. The system for measuring latency of claim ~~31~~34, wherein the read-out display comprises a display of the device and wherein the system comprises a communication interface for communicating with the device.
36. The system for measuring latency of claim 32, wherein the communication interface comprises a wireless network.
37. The system for measuring latency of claim 4, wherein the computational engine comprises a processor of the device.
38. The system for measuring latency of claim 4, wherein the computational engine comprises a processor on an external device, the external device being operatively connected to the first and second sensors, and to the output device.
39. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the first sensor via a wireless communication interface.
40. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the first sensor via a wired communication interface.
41. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the second sensor via a wireless communication interface.
42. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the second sensor via a wired communication interface.

43. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the output device via a wireless communication interface.
44. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the output device via a wired communication interface.
45. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the first sensor via a wired communication interface and the second sensor via a wireless communication interface.
46. The system for measuring latency of claim 38, wherein the computational engine is operatively connected to the second sensor via a wired communication interface and the first sensor via a wireless communication interface.
47. The system for measuring latency of claim 4, wherein the body comprises a distal end having a contact area, the contact area comprising a material having properties such that physical contact between the contact area and a touchscreen of the device will produce touch input to the device.
48. The system for measuring latency of claim 4, wherein the second sensor comprises an audial sensor.
49. The system for measuring latency of claim 4, further comprising a contact area, at least a portion of the contact area being formed from discrete pieces of dielectric or conductive material that are brought into physical contact with the user interface by one or more linear actuators, the linear actuators and pieces of dielectric or conductive material being controlled by signaling from the computational engine.
50. The system for measuring latency of claim 4, further comprising circuitry for measuring a position and a velocity of the system as it is moved across the user interface.
51. The system for measuring latency of claim ~~38~~50, wherein the system is configured to use data representing the measured position and velocity to determine end-to-end touch-drag latency of the device.

52. The system for measuring latency of claim 4, wherein the body comprises a common housing and a stable housing, the stable housing comprising a material which is not sensed by the user interface of the device, the common housing being movable with respect to the stable housing when the stable housing is resting on the user interface of the device, such that the common housing can be moved into contact with the user interface in a repeatable manner.
53. The system for measuring latency of claim 4⁵², further comprising an actuator for moving the common housing into contact with the user interface.
54. The system for measuring latency of claim 4, wherein the indication of a measurement is a qualitative indication.
55. The system for measuring latency of claim 4, wherein the indication of a measurement is a quantitative indication.
56. The system for measuring latency of claim 4, wherein the output device is at least one selected from the set of: a graphical display, a speaker, a light, a light reflective indicator and a haptic output.
57. A system for measuring latency in a device which includes a user interface that receives user input and provides output in response thereto, comprising:
- a body separate from the device;
 - a signal emitter that emits a signal at a first time that a controller of the device would interpret as a physical touch event, whereby a simulated physical touch event is triggered in the device;
 - a sensor for detecting a response output from the device at a second time, the response being responsive to the touch event;
 - a computational engine for computing a time differential between the first time and the second time; and,
- an output configured to output a measurement of latency in the device, the measurement being reflective of the time differential between the first time and the second time.

- ii) receiving a first signal from a first sensor, the first signal corresponding to the time of the touch event on the device;
 - iii) receiving a second signal from a second sensor, the second signal also corresponding to the time of the touch event on the device;
 - iv) using the first signal and the second signal to provide an output signal comprising time data, the time data being reflective of a measurement of latency between the time of the touch event as detected by the first sensor and the time of the touch event as detected by the second sensor.
65. The method for generating latency data according to claim 64, wherein the first sensor is a touch sensor and the second sensor is a sensor selected from the group consisting of: accelerometer, magnetometer, microphone, or proximity sensor.
66. A system for measuring latency on a device under test, the device under test including a user interface that receives touch input and provides output in response thereto, comprising:
- a device holder configured to receive the device under test;
 - an input proxy device;
 - at least one mechanical motor configured to move the proxy device with respect to the device under test; and,
 - a ground-truth measurement apparatus configured to record input proxy device movement with respect to the device under test and to record a representation of movement generated by a test application running on the device under test, whereby a ground-truth is provided.
67. The system for measuring latency on a device according to claim 66, wherein the representation of movement comprises an ink stroke displayed on the device under test.
68. The system for measuring latency on a device according to claim 66, wherein the at least one mechanical motor comprises a motor configured to move the device under test, such that the input proxy device is moved with respect to the device under test.